Comet Smash Reader Reports

ASTRONOMY®

December 1994 $4.95

Robo-Astronauts To Explore the Planets

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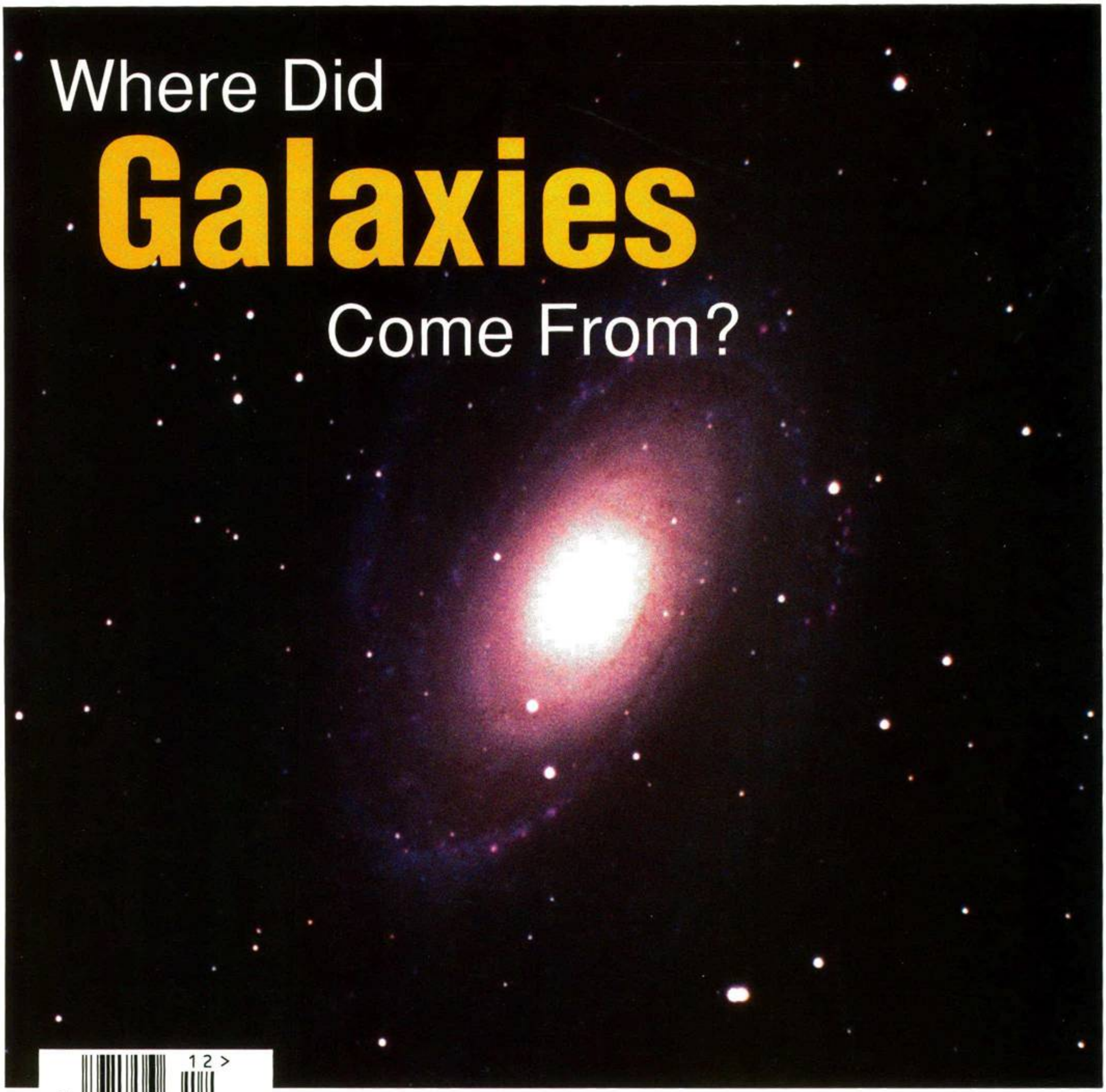
Where Did Galaxies Come From?



- **Telescope Test: Celestron's Compact 8–inch**
- **Hubble Explores the Crab Nebula**

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MEADE
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12" LX200
10" LX200
8" LX200
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Supplied complete per catalog specifications**:

8" LX200 Schmidt-Cassegrain	**$2495.**
10" LX200 Schmidt-Cassegrain	**$2895.**
12" LX200 Schmidt-Cassegrain	**$3995.**

Packing & shipping in 48 states: 8"—$105; 10"—$145; 12"—$215.

- **All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.
- For dealer or catalog information see the **Meade Starfinder Reflecting Telescope** ad in this issue.

LX200

SCHMIDT-CASSEGRAINS

Now with *one arc-minute* pointing accuracy and 64,350-object onboard database as *standard-equipment!*

Meade 8", 10", and 12" LX200 models with standard-equipment High-Precision Pointing™ software now automatically GO TO any input RA and Dec, or to any object in the 64,350-object database, to a pointing precision within one arc-minute!

New Meade Version 3.30 software and high-resolution encoders, used in conjunction with the unique Meade SYNC command, now yield the most precise automatic slewing ever offered in a commercial telescope, an observatory-level of precision and *more than 5 times the precision obtainable with any competing computer-controlled telescope.* Data entry through the telescope's keypad hand controller may be made either from the onboard 64,350-object library database *(see description at right)* or by inputting the desired object's RA and Dec.

HIGH PRECISION HP POINTING

LX200's with High-Precision Pointing have the HP logo-plate affixed to the telescope's drive base.

Such precise object-acquisition, selectable during either altazimuth or equatorial operation of the LX200, has numerous important implications for the serious observer:

☐ Use the GO TO command to *find and center an object in the field of a 4mm eyepiece.*

☐ With other telescopes, acquiring even bright objects on the chip of a CCD imager is generally a chore at best, searching and slewing by trial-and-error until at last the object is positioned on the chip. The LX200's High-Precision Pointing places *every* object on *every* CCD chip *every* time.

☐ Suppose you wish to CCD-image a supernova in an 18th magnitude galaxy—a galaxy invisible *except* through the process of CCD imaging. With Meade High-Precision Pointing, the galaxy can be placed on the chip of every commercially-available CCD unit.

☐ Photographing or imaging faint objects such as the planet Pluto, or comets and asteroids near the photographic limit of the telescope, and plotting the motion of these objects night-to-night, now becomes practical, since the photograph or image may be taken *without the observer ever having seen the object visually,* but knowing that the LX200 will place the object precisely in the telescopic field.

All Meade LX200 models now include a 64,350-object onboard database as standard equipment.

Imagine having 64,350 celestial objects at the tip of your finger: 64,350 objects that you can actuate and center in the telescopic field just by entering and pressing GO TO on the hand controller. **More than 6 times the size of object libraries included with competing telescopes,** the Meade 64,350-object library includes an incredible array of phenomena—virtually a lifetime of deep-space study, even for the advanced observer:

12,921	galaxies from the Uppsala General Catalog; the complete UGC catalog.
7,840	objects from the New General Catalog; the complete NGC catalog.
5,386	objects from the Index Catalog; the complete IC catalog.
21,815	variable stars; the complete listing from the General Catalog of Variable Stars.
15,928	stars from the Smithsonian Astrophysical Observatory (SAO) catalog of stars brighter than 7th magnitude.
351	alignment stars for the LX200 telescope.
110	Messier objects; the complete listing.
8	major planets from Mercury to Pluto.
64,359	objects, total

SPECIFICATIONS: 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel display on the drive base; manual and electric slow-motion controls on both axes; keypad handheld controller with digital readout display, permanently programmable Smart Drive™, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,350-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (for field operation from any 12v. auto cigarette lighter plug, use the Meade #1812 Electronic DC Adapter, a 4-oz. unit available optionally); 8 x 50mm viewfinder with crosshairs; 1.25" diagonal prism (8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (8", 10") or giant field tripod (12"); foam-fitted carrying case; complete operating instructions.

ADVANCED PRODUCTS DIVISION

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Luke Dodd

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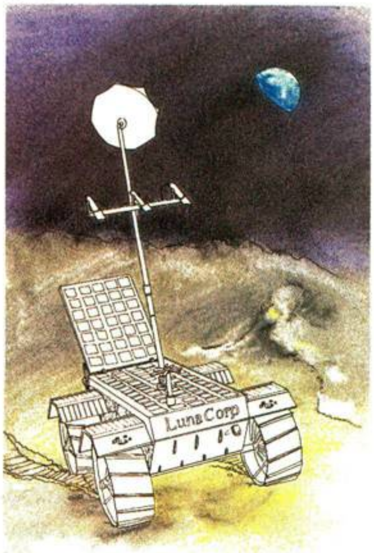

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New Hubble images of this supernova remnant reveal surprising complexities in its gaseous filaments and the area immediately surrounding the Crab Pulsar. By Richard Talcott.

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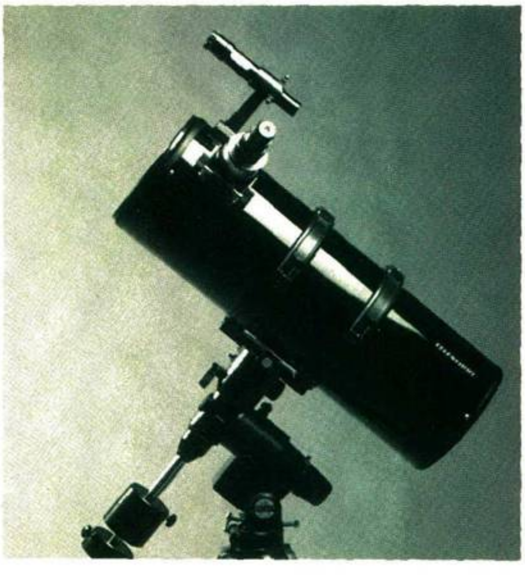

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COVER

SPIRAL GALAXY M81 and millions of other galaxies evolved from the sea of chaotic particles in the early universe. For more on galactic origins, see page 28. Photo by Tony and Daphne Hallas.

BEHIND THE SCENES

Something from Nothing

A long, long time ago, when no one was looking, the universe pulled off the greatest magic trick ever done. In effect, it made something out of nothing. Starting out in an extremely smooth state — the Big Bang — the universe changed into a very lumpy state — today's cosmos full of galaxies, stars, and who knows what else. And it did it all in no time flat, comparatively speaking. Astronomers still can't figure out quite how it happened.

Countless people have debated where the universe came from; cosmologists on the other hand would be overjoyed if they could answer a much smaller question: Where did galaxies come from? As Ron Cowen points out in the feature story on page 44, the origin of galaxies is a truly knotty problem. And it's been made worse by cosmologists' own high-quality observations.

The problem began in 1965 with the discovery of the cosmic background radiation, the Big Bang's fading echo. From then through the 1980s, repeated careful measurements of the background radiation showed that it was perfectly smooth.

Which poses a big problem if you're a theoretician trying to explain where galaxies come from. These, it is thought, can form only from fluctuations of density in the Big Bang — from primordial "lumps" in other words. The chain of logic is stark: No lumps, no structure. No structure, no galaxies. No galaxies, no us to sit around and ponder the nature of it all.

In 1989 NASA launched the Cosmic Background Explorer satellite to look at the Big Bang afresh. Its data showed that the Big Bang was indeed almost perfectly smooth — but not quite. More sensitive than previous instruments, COBE found the faintest of ripples in the background radiation. They weren't much, but these tiny seeds could be enough to grow a universe from.

Still they offered theoreticians only scant comfort. The reason is twofold. First the ripples are small, maybe too small to make galaxies, even given all the time elapsed since the Big Bang. Second, other observations made with the Hubble Space Telescope and the largest instruments on the ground have reached deep into the universe to find that galaxies — and clusters of them — go back practically all the way to the Big Bang itself. Caught in the narrowing gap between the Big Bang and the latest discoveries of ever more distant galaxies, cosmologists have begun to feel trapped in a kind of Tunnel of Doom, with the walls drawing ever closer.

So where's the way out? Caught in a similar pickle, Indiana Jones always had a trick or two up his sleeve. But Cowen's conversations with cosmologists show that today's bold explorers have no such clever solutions. Somehow, the universe has made everything around us out of next to nothing. Neat trick. Now if only we could see how it was done . . .

Sincerely,

Robert Burnham
Editor

LETTERS

Reading the Trees

I enjoyed Bruce Bond's historical overview "100 Years on Mars Hill" on the Lowell Observatory (June 1994). One important, albeit indirect contribution of the observatory was not mentioned. Alfred Douglass, Lowell's assistant, was interested in sunspots and their possible effect on climate. Because of the extreme (but variable) aridity of the desert Southwest — which also made the region ideal for astronomical observations — Douglass found striking regularities in ring growth patterns from trees at widely separated locations within Arizona. These led him to link climate with tree growth by noting dramatic changes in the width of tree rings as drought years came and went.

Douglass' systematic observations resulted in the development of dendrochronology, the use of tree rings to date past events. The principles first established by Douglass have allowed archaeologists to reconstruct past climates as well as date ruins and even ancient earthquakes. For an excellent summary of how the field founded by Douglass has grown, see H.C. Fritts, *Tree Rings and Climate* (Academic Press, 1976). — *Erik Hobbie, Charlottesville, Virginia*

Only Pure Sensations Need Apply

I found Randall Wehler's Viewpoints article "Imagining vs. CCD Imaging" (August 1994) rather churlish. He complains that looking at CCD images of astronomical objects is somehow more artificial than viewing directly through the telescope, as if one more step in the process greatly diminishes the experience. I trust he never watches television or listens to a symphony on a CD for fear the intervening phosphor or digital data will lessen his enjoyment.

There's no such thing as "pure"

(continued on page 14)

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U.S. and International Newsstand Distribution
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Canadian Newsstand Distribution
Telemedia Dist., Toronto, Ontario M4S 3B3

ASTRONOMY is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Editorial phone: (414) 796-8776; advertising: (800) 558-1544; customer service: (800) 446-5489; subscriptions: (800) 533-6644 7 days a week, 24 hours a day; fax (414) 796-0126. Copyright © 1994 Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without permission. Second-class postage paid at Waukesha, WI, and additional mailing offices. Allow 6 to 8 weeks for new subscriptions and address changes. Subscription price: 1 year $27. Canadian and foreign: 1 year $38, GST (#R122713209) included; please remit in U.S. funds. Not responsible for unsolicited materials. POSTMASTER: Send address changes to Astronomy, 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Canadian second-class postal permit no. 545775. Printed in the U.S.A.

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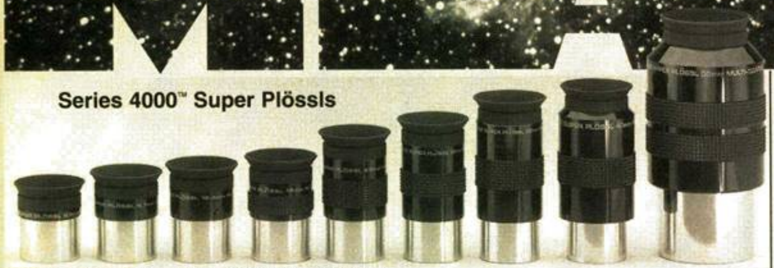
Series 4000™ Super Plössls



Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types for 1994, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm each: **$87.95** (3.29)

32mm (52°); **40mm** (44°) each: **109.95** (3.79)

56mm (52°; 2") **229.95** (5.48)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

F/6.3 FOCAL REDUCER/FIELD

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

SALE! Meade® Schmidt-Cassegrain Accessories

Extended through November 30, 1994, buy Meade premium-quality Schmidt-Cassegrain accessories at special sale prices and save up to 16%!

Series 4000 f/6.3 Focal Reducer/Field Flattener: Regular $129.95; Sale Price $114.95. Save 11%.

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Variable Tele-Extender for SCT: Regular $39.95; Sale Price $35.95. Save 10%.

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Series 4000 Super Plössl 56mm Eyepiece (2"): Buy one eyepiece at the regular price of $229.95 and receive the #929 2" Diagonal Mirror FREE.

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All prices plus shipping, as noted in product descriptions. This offer is valid between June 20 and November 30, 1994, at participating Meade dealers and is subject to product availability.

Series 4000™ Super Wide Angle

For exquisite wide-angle images at low-to-medium powers, ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8, 18, and 24.5mm are superb complements to the #140 Barlow.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $159.95** (3.49); **18mm: 169.95** (3.69); **24.5mm: 199.95** (3.89); **32mm** (2"): **279.95** (4.78); **40mm** (2"): **339.95** (5.48)

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The ultimate eyepieces; extreme image sharpness over an amazing 84° field.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)–**4.7mm: $179.95** (3.29); **6.7mm: 219.95** (3.29); **8.8mm** (1.25"/2"): **269.95** (4.78); **14mm** (1.25"/2"): **329.95** (5.48)

Series 4000™ #140 2x Apochromatic Barlow Lens

The most advanced Barlow Lens available for commercial telescopes; includes 3-element, air-spaced optics, multi-coated. Unmatched in image resolution, contrast and color correction. Accepts 1.25" eyepieces. Lens dia. 28mm; clear aperture 26mm.

$79.95 (3.29)

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The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce excellent results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$57.95** (3.45) **Any 2: $52.95** each;

Any 3: $48.95 each; **Any 4 or 5: $46.95** each.

Series 3000™ Plössl 40mm

A perfect complement to the Series 3000 Plössls at left, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, multi-coated. Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

Series 4000 Photo-Visual Color Filters (1.25")—Made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

	each **$14.95**	(2.29)
Moon Filter #ND96–Reduces brightness by 87%.	**16.95**	(2.29)
Set #1–4 filters: #12, #23A, #58, #80A	**54.95**	(2.98)
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#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

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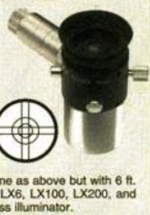
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95**	(2.98)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95**	(3.29)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95**	(3.29)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. **Internal batteries included.** Multi-coated optics. Bullseye reticle. 1.25"

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Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

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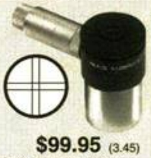

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. **Batteries included.**

$99.95 (3.45)

MA 12mm—Same as above but with cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **$99.95** (3.79)

Camera Adapters (1.25" & .965")

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95 (2.98) **1.25": $29.95** (2.98)

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Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

Tele-Extenders

For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to any eyepiece-holder. Use with T-mount for your camera.

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Variable Tele-Extender: Sliding cell, with lock, permits wide range of projection magnifications with the same eyepiece.

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T-Adapters for SCT's

For Prime Focus photography with any Meade or Celestron SCT. Use with T-Mount for your 35mm camera.

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2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

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An improvement on the traditional Kellner design, these 3-element Modified Achromatic eyepieces give sharp, faithful, well-corrected images of the moon, planets, and deep-space at an economical price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (2.98)

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■ Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.

■ Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

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Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders: 800-843-4780; Info.: 818-505-8424.

CITY CAMERA, Dearborn, MI.
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Orders & Information: 416-783-4140.

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$565.

12.5" f/4.8
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Shown with optional #637 6 x 30mm or #545 8 x 50mm Viewfinders

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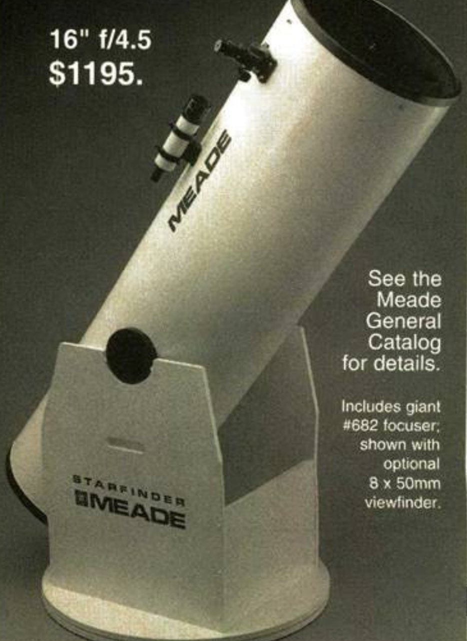
Starfinder Dobsonian 16

16" f/4.5
$1195.



See the Meade General Catalog for details.

Includes giant #682 focuser; shown with optional 8 x 50mm viewfinder.

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- **To Order:** Contact one of the authorized mail-order dealers on the facing page.

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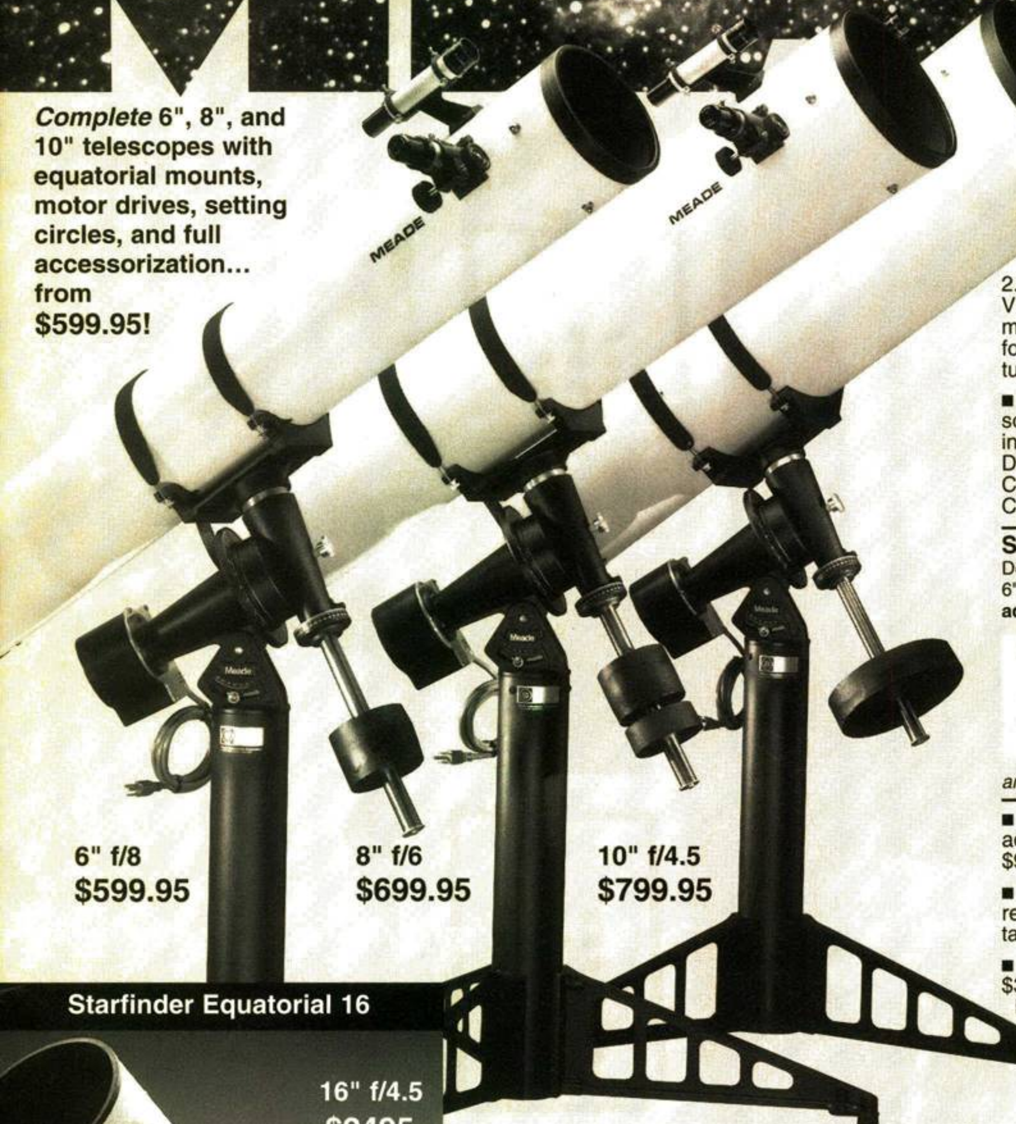

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$699.95

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- All prices shown are suggested USA mail-order retail prices, not including any applicable sales taxes.
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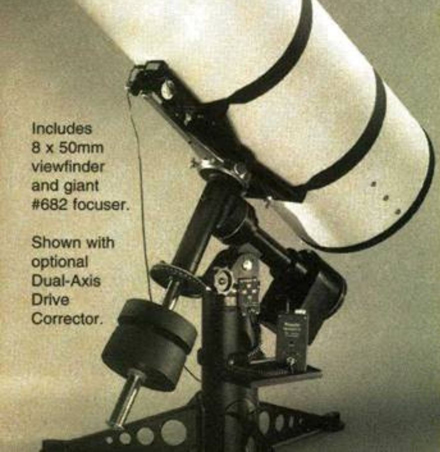
- For further information call Meade Instruments at 714-756-2291 or contact one of these authorized mail-order dealers:

Starfinder Equatorial 16



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$2495.

See the Meade General Catalog for details.

Includes 8 x 50mm viewfinder and giant #682 focuser.

Shown with optional Dual-Axis Drive Corrector.

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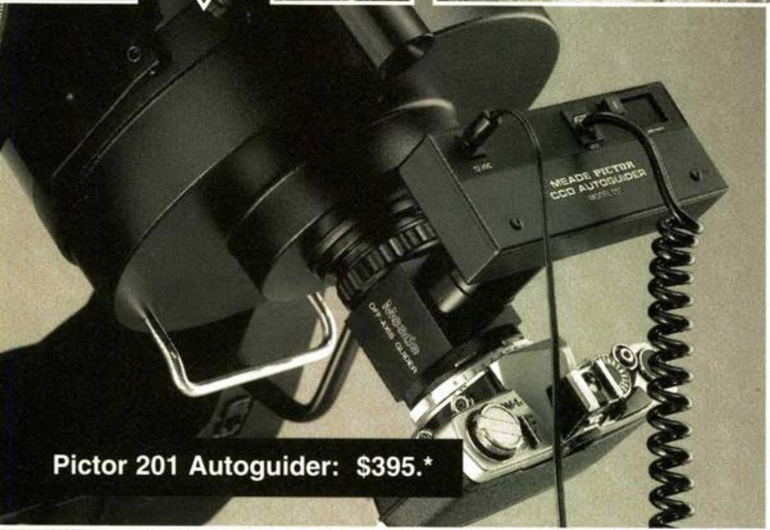
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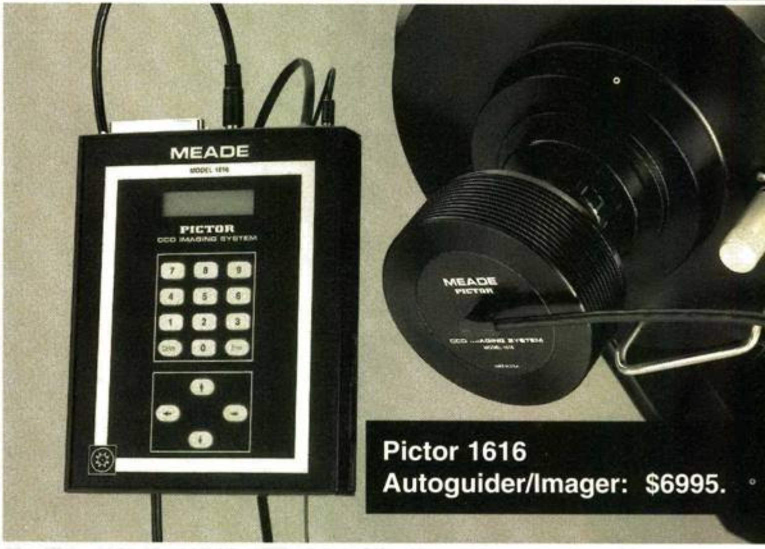
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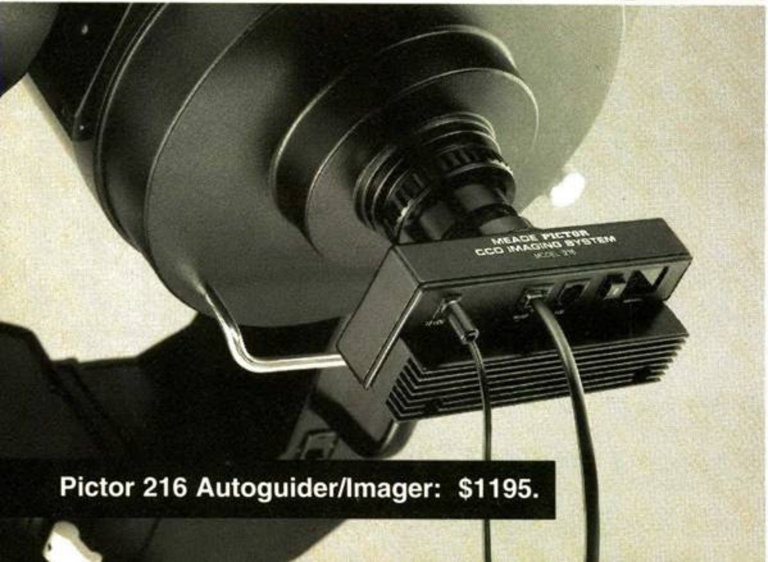
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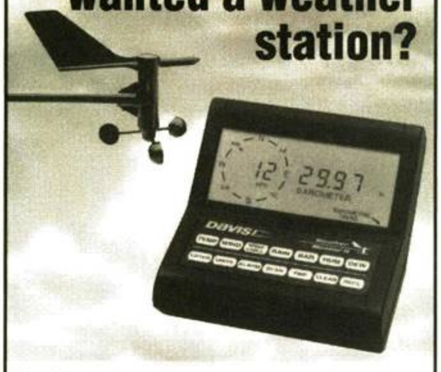

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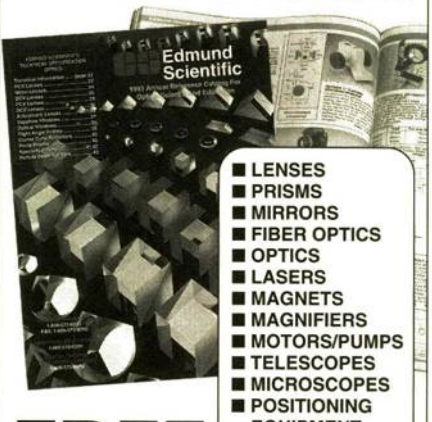

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sensation. Our minds register only a fraction of the data our eyes receive just as we interpret only a portion of the waves our eardrums receive. Is a telescopic view of the Moon less "real" than a naked-eye view? Should we all demand seats on the space shuttle so our views are not distorted by Earth's atmosphere?

I've no brief for or against CCD images. They're here whether I like it or not. But I know they will delight many. Who can object to that? — *Barry Evans, Palo Alto, California*

"I've no brief for or against CCD images. They're here whether I like it or not."

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Which Way to Planet Earth?

In "The Moon Comes into Focus" by Richard Talcott (September 1994) you published a picture of the Moon's south pole taken by the Clementine spacecraft. Which direction is facing Earth? — *Chris Mallabon, Edmonds, Washington*

— If you envision the photo as a clockface, the line of 0° lunar longitude, which marks the average center of the Earth-facing hemisphere, runs straight up the page toward noon. The large crater at about 4 or 5 o'clock is Schrödinger, the one at 7 to 8 o'clock is Zeeman; both are on the farside. The dark splotch inside Schrödinger is a volcanic crater (according to Gene Shoemaker) whose ejecta-debris lies on top of secondary impact craters from Antoniadi, which is the half-visible largish crater at about 6 o'clock.

Disappointed in Perseids

I've just bought the August 1994 issue and have read Philip Bagnall's article on the Perseids with a bit of disappointment. I get the impression that Bagnall is not completely knowledgeable about recent developments regarding the shower. For instance, we are told that the Moon was "out of the way" last year, but in fact we had a waning crescent causing a fair amount of interference. There has been no "slow but steady increase in Perseid activity . . . over the last few seasons." Rather, a new peak has appeared, undoubtedly associated with recently ejected debris from Swift-Tuttle, some 12-18 hours ahead of the regular maximum. If anything, this new peak was actually stronger in 1991 and 1992 than in 1993. Mr. Bagnall might have mentioned this new peak and would have done his fellow U.K. citizens a service in that way. — *Neil Bone, Chichester, West Sussex, England*

— To see how the shower did turn out, turn to Reader Reports on page 89.

The Queen Is Not Amused

For more than a decade I've enjoyed your fine magazine. While reading the September 1994 issue I was drawn to Deborah Byrd's story of Cassiopeia, along with the illustration showing its stars. The illustration shows Cassiopeia's stars superimposed on a figure of the Queen, but upside-down relative to the way it should be. Alpha and Beta Cassiopeiae are thus shown below the knee line, hardly the correct position for a queenly breast and hand. — *Frank B. Collins, Tererro, New Mexico*

NASA Eclipse Publication Available

The bulletin *Total Solar Eclipse* of 1995 October 24 (NASA RP 1344) is now available. This 74-page publication features detailed predictions for the event, weather prospects for 400 cities in the path of totality, maps, and voluminous data. A limited number of these publications is available at no cost, but we ask that requests — a single copy per request, please — be accompanied by a 9" by 12" SASE with sufficient postage for 11 ounces. — *Fred Espenak, Planetary Systems Branch, Code 693, Laboratory for Extraterrestrial Physics, NASA Goddard Space Flight Center, Greenbelt, MD 20771.*

If I Had a Hammer . . .

Build a planetarium at home? Yes, there are actually a number of us who have undertaken the task and are enjoying the universe inside our houses. ASTRONOMY readers who are interested may contact the newly formed Home Planetarium Association by writing to me. — *Gary Likert, 1203 Highway 25, Gallatin, TN 37066, (615) 734-4147.*

Correction

The photo of M51 and its attendant supernova on page 84 of the July issue was taken by George Greaney and Dean Easton. ☐

ASTRONOMY welcomes feedback. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or on the Internet, use 72000.2704@CompuServe.com. Letters may be edited for length and clarity.

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VIEWPOINTS

The Rest of the Story... from Jupiter

by Jonathan Katz

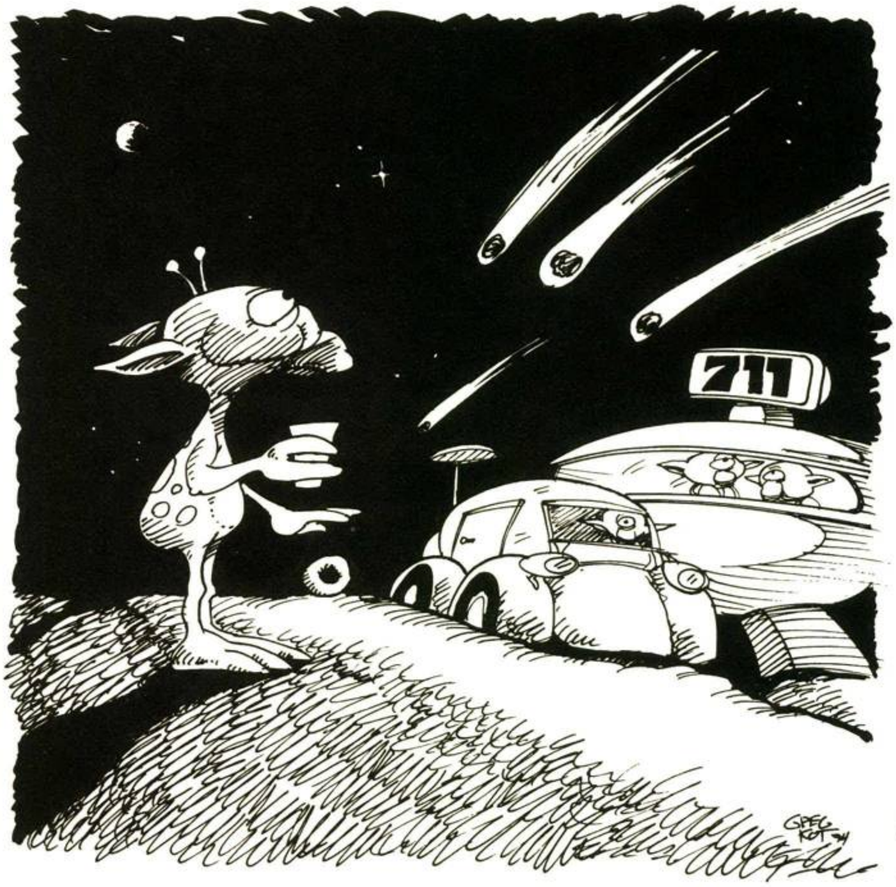
Yo, Earthlings! You think you got it tough? Try spending a week on the receiving end of the "astronomical spectacular of a lifetime." For you it's just a chance for a bunch of insomniac weirdos to aim their telescopes at something other than the blonde across the street. For us, it's murder. Worst weather I've lived through: completely overcast with a 100 percent chance of comet chunks.

Of course, it's always cloudy up here. And you think you got acid rain? Spent the weekend waxing my car, got stuck in a hydrochloric storm. Took off the wax, the paint, the vinyl trim, and damn near ate the tires. Insurance won't cover cause it was an act of God — something He Himself did, apparently.

At best, Jupiter takes some getting used to, what with high gravity, short days, long years, and too much methane in your air. But this Levy-Shoemaker thing was ridiculous. We knew about it for months, but did the government do anything? Hell, no. Just paraded out a bunch of generals to bitch about killing the Star Wars program. "Not a thing we can do about it," they said. "With existing technology we have a one in three chance of knocking down a Scud missile. And you want us to stop an incoming Mount Everest? No can do, fellas. You might as well sit back and watch, 'cause we're gonna get creamed."

The Coast Guard tells people to evacuate, but they don't listen. Just run down to the local 7-11, buy a box of candles and some soup. Like its all going to blow over or something. Idiots. This isn't rain we're talking here. It's solid rock, and not just a light dusting either. The damn fools sit home, staring at the sky, at the last minute thinking they can duck into the basement. And they get squashed. At least they don't complain afterwards.

And another thing. This so-called celestial event screwed up my TV reception something terrible. I'm watching Europa play Io in the Jupiter Cup semifinals, and you know soccer. Two days of scoreless tie, then penalty kicks. So the guy from Io is just winding up to take his shot when a fragment checks in. Million



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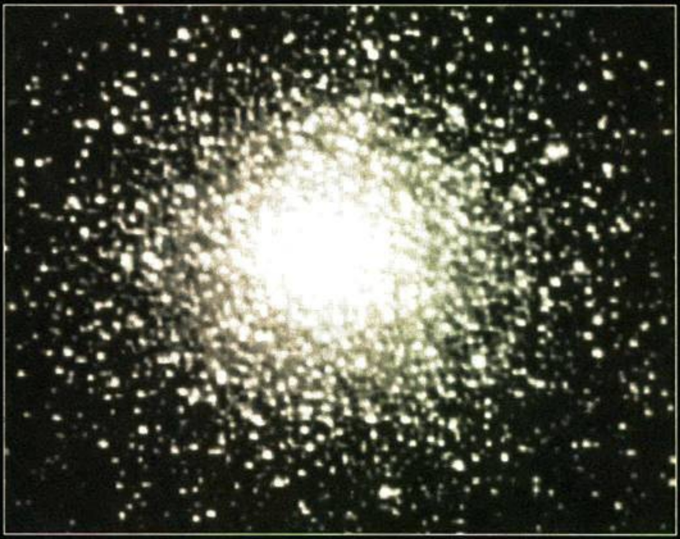

M3 Globular Star Cluster. *Using "cluster variables" as a reference the distance of M3 is in the range of 35,000 to 40,000 light years. With an actual diameter of about 220 light years the total population is about half a million stars, with a total luminosity about 160,000 times the light of the sun. This remarkable 120 second ST-6 CCD image contains stars to magnitude 19.8. It was taken at the prime focus of a 20 inch, f/12 telescope, processed with CCDOPS and then post processed with The Sky astronomy software from Software Bisque. Courtesy Mike Palermiti, Jupiter, Florida.*

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megatons of slag, at 130,000 miles an hour, and *that's* the ball game. I mean, its Splat City out there. Gets both teams, the entire stadium, and everything else in a 20-mile radius. Dead *and* buried.

Of course, the surviving locals are all set. Game was blacked out in their area, so they're watching videos. Us? Channel just goes off the air. Ten minutes later they're back on, with reruns of the O.J. hearings. *Enough* already.

"This Levy-Shoemaker thing was ridiculous. Worst weather I've lived through: total overcast with 100 percent chance of comet chunks."

One piece smacked out the Ganymede exits on Interstate 1143. The highway crews just shrugged their shoulders. Boulder about a half-mile high — they said removing it was, quote, "not in their job description," unquote. Wimps! Now I gotta take surface roads — adds about an hour to my commute each way. And with days only 9 hours long, don't ask me when I'm supposed to sleep.

And the worst of it is, that stuff is permanent. Doesn't melt. Doesn't run down the drain. Doesn't even wear off, like when you get Great Red Spot on your hands. It just sits there and gets in your way for the next zillion years or so.

Government scientists are telling us the effects are "only temporary?" Don't let 'em kid you; that comet cleaned our sink. Dings in the rings. Holes in the poles. Tides all washed up. And my favorite ski resort took a direct hit. Had a condo in the mountains up there, now it's in a crater, under 3,000 feet of liquid ammonia. Insurance company says I can rebuild but they won't pay for the cost of the land, because it's "still there." I should drain the lake? Either way, my premiums are going through the roof.

On second thought, I've had it. No sense hanging out, waiting to get whacked again. Get me a shuttle ticket, I'm outta here. I think I'll try Mercury next. Guaranteed sunshine. I know it's hot, but it's a dry heat, right? And any comets that pass through will probably fall into the Sun where they belong. As for Earth, I've been there. You can keep it.

And just remember: However bad you think things are, they're worse on Jupiter. □

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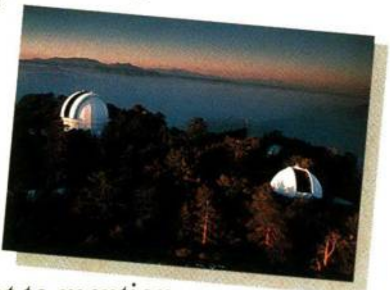

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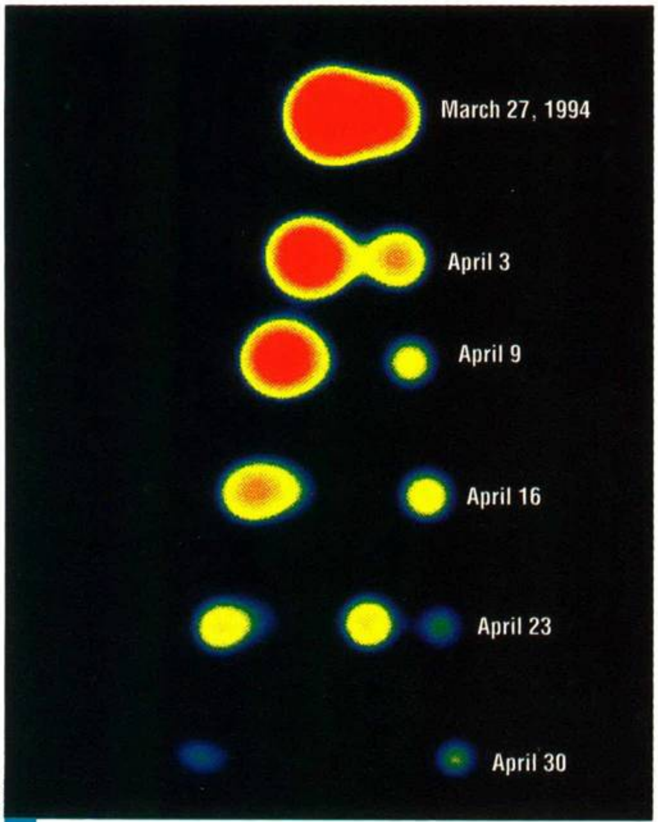
Superfast Object in Milky Way

Researchers using the Very Large Array radio telescope in New Mexico have discovered a small, powerful object in the Milky Way Galaxy shooting out material at nearly the speed of light, a feat previously known to occur only in the massive cores of active galaxies. Because the material is moving almost directly toward us, it appears to be traveling faster than the speed of light — a phenomenon called superluminal motion. This is the first superluminal motion ever detected within our Galaxy.

Writing in the September 1, 1994 issue of *Nature*, astronomers Felix Mirabel of the Center for Studies at Saclay, France, and Luis Rodriguez of Mexico's National Autonomous University and National Radio Astronomy Observatory, report a remarkable ejection event in the X-ray source known as GRS 1915+105. This object shot out material in opposite directions at 92 percent of the speed of light. The event ejected a mass equal to one-third that of the Moon with the power of 100 million Suns. Such powerful ejections are known in distant active galaxies and quasars. But GRS 1915+105 lies within the Milky Way Galaxy, only 40,000 light-years away. It is also much smaller and less massive than the core of a galaxy, so the astronomers were quite surprised to find it capable of accelerating material to such speeds.

Mirabel and Rodriguez believe GRS 1915+105 is likely a double-star system, with one member either an extremely dense neutron star or a black hole. The dense star is the central object of the system, with great mass and a strong gravitational pull. It is surrounded by a disk of material being drawn into it from a more-normal companion star. The central object is emitting jets of subatomic particles from its poles and it is in these jets that Mirabel and Rodriquez discovered the rapidly moving material.



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EXPANSION FASTER THAN LIGHT was the apparent result when a Milky Way radio source ejected material at nearly the speed of light almost directly toward us. Such "superluminal" velocities have been seen in the cores of active galaxies, but never before needed in the Milky Way.

Galaxy's Halo May Trace Dark Matter

A faint halo of light surrounding the edge-on spiral galaxy NGC 5907 in the constellation Draco provides a clue about its dark matter. The halos of most galaxies decline quickly in brightness away from the galaxies' centers but the brightness of NGC 5907's halo declines slowly. In fact, the brightness mimics how dark matter is distributed through the galaxy's outer regions. (Astronomers infer the existence and location of dark matter in the galaxy from the motion of gas in its disk.)

Penny Sackett of the Institute for Advanced Study in Princeton, New Jersey, and a team of researchers described their observations of the halo in the August 11 issue of *Nature*. They measured the halo's brightness using a 36-inch telescope and CCD camera at Kitt Peak National Observatory, located outside Tucson, Arizona. Because the halo is 200 times fainter than the natural sky glow, the group used sophisticated calibration techniques to determine its brightness.

The halo light results either from normal stars arranged in a way that traces the distribution of dark matter or from the faint glow of the dark matter itself. In the latter case, the astronomers rule out the possibility that the dark matter consists of brown dwarfs because they would

Joseph L. Hora, UH, and William B. Latter, NRAO

TWO SHELLS OF GLOWING GAS form the lobes of the butterfly-shaped nebula in Ophiuchus named Minkowski 2-9 (also known as PK 10+18.2). Emission by molecular hydrogen in the outer shell glows red and that by atomic hydrogen in the inner shell appears blue. Joseph Hora of the University of Hawaii and William Latter of the National Radio Astronomy Observatory took this infrared false-color image using the 2.2-meter UH telescope on Mauna Kea in Hawaii. They describe the discovery of the double-shell nature of the nebula in an article to appear in the *Astrophysical Journal*.

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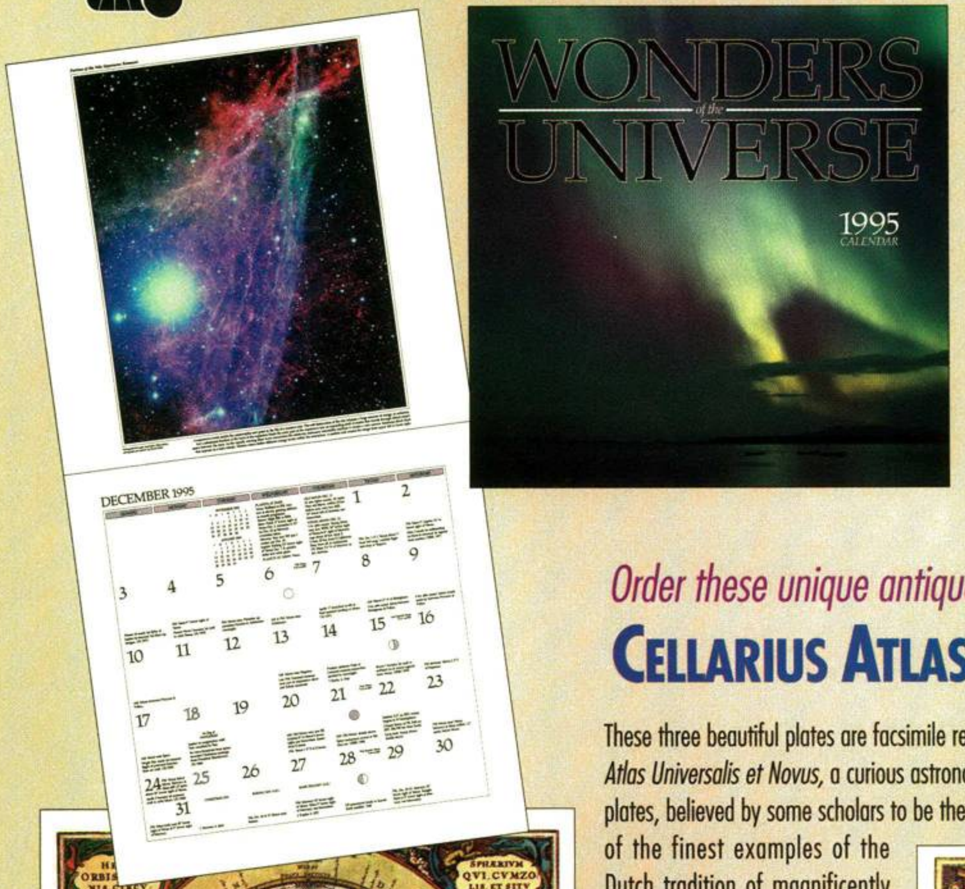

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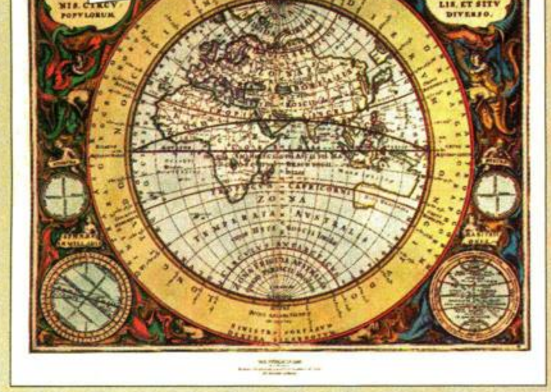

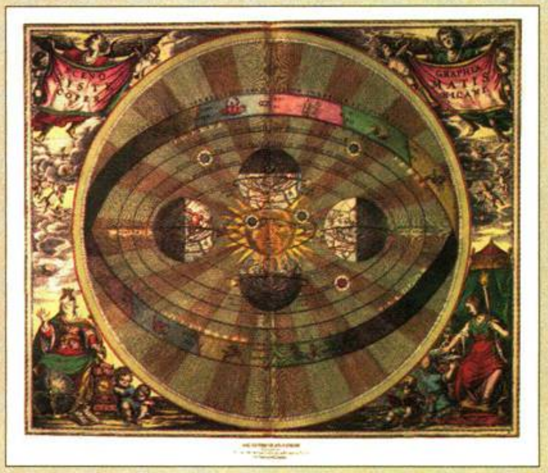

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be too faint to produce the halo's brightness. Instead they suggest that the halo contains low-mass M-type dwarfs having about one-tenth the Sun's mass. To further study this possibility, the astronomers will now try to determine the color of the halo to see if it's similar to that of M dwarf stars.

NOAO

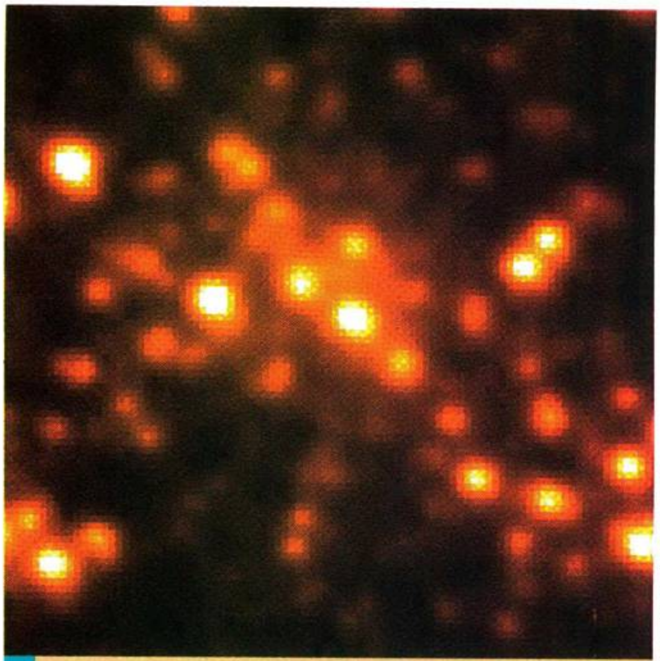
A FAINT HALO SURROUNDS the edge-on spiral galaxy NGC 5907. The glow comes either directly from the dark matter or from normal stars arranged the same way as the dark matter.

M87 Jet: Faster Than Light?

Astronomers comparing seven images taken between 1982 and 1993 with the Very Large Array radio telescope located near Socorro, New Mexico, have recently discovered that the well-known jet emanating from M87 appears to be moving at 2½ times the speed of light. This illusionary faster-than-light effect, called superluminal motion, occurs when a gas jet streaming in Earth's direction almost keeps pace with the light it emits. It was previously seen only in distant galaxies and quasars. Its discovery in M87, an elliptical galaxy in Virgo some 50 million light-years away, has astronomers thinking that the phenomenon may be common for reasons other than a jet's chance alignment with Earth.

"Because we expect these jets to be randomly oriented in space, only a small fraction should point toward Earth," says co-discoverer John Biretta of the Space Telescope Science Institute in Baltimore, Maryland. "That's why we expect to see superluminal motion only in very distant objects, where we are sampling a huge volume of space." Most of M87's jet does not point in our

(continued on page 26)



P. Dubath and G. Meylan, ESO

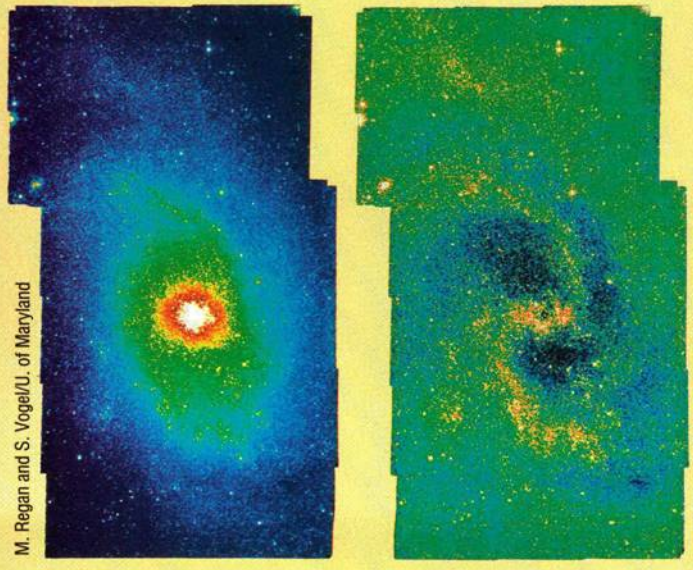
Cluster Core Closeup

M15 glows up close and personal in this CCD image shot through a violet filter using the European Southern Observatory's New Technology Telescope. This view takes in the 5" by 8" center of the globular star cluster located in Pegasus. ESO astronomers Pierre Dubath and Georges Meylan used the NTT to take five high-resolution spectra of the cluster's core. According to a recent paper published in *Astronomy and Astrophysics*, they found that two of the brightest central stars, separated by 2.5", might be responsible for spectrographic observations of large rotational or streaming motions across the center of M15. These suggested a massive black hole in the center of M15. In previous, lower-resolution spectrographic surveys, measurements interpreted to represent motions across the entire cluster's center were biased by the stars' motions.

Infrared Views of M33

The graceful spiral arms of M33, a nearby spiral galaxy in the constellation Triangulum, fade away and the overall distribution of stars comes out when viewed at the near-infrared wavelength of 1.27 microns (right). In September and October of 1992, Michael Regan and Stuart Vogel of the University of Maryland in College Park observed the central 15' by 30' of M33 in the near infrared to see how the galaxy's mass is distributed. (Previous observations had been made at optical wavelengths, which tend to trace young, massive stars and not the older stars that dominate the mass distribution.)

The astronomers then modeled the disk and spheroidal components of the galaxy and subtracted that out of the image (far right) to reveal two spiral arms in the inner 9' of this grand-design galaxy (see "What Puts the Spiral in Spiral Galaxies?", September 1993). Regan and Vogel also detected a faint, bar-shaped excess in the central 1.5' of the galaxy, but are not sure yet whether this is an inward extension of the spiral arms or a true bar.



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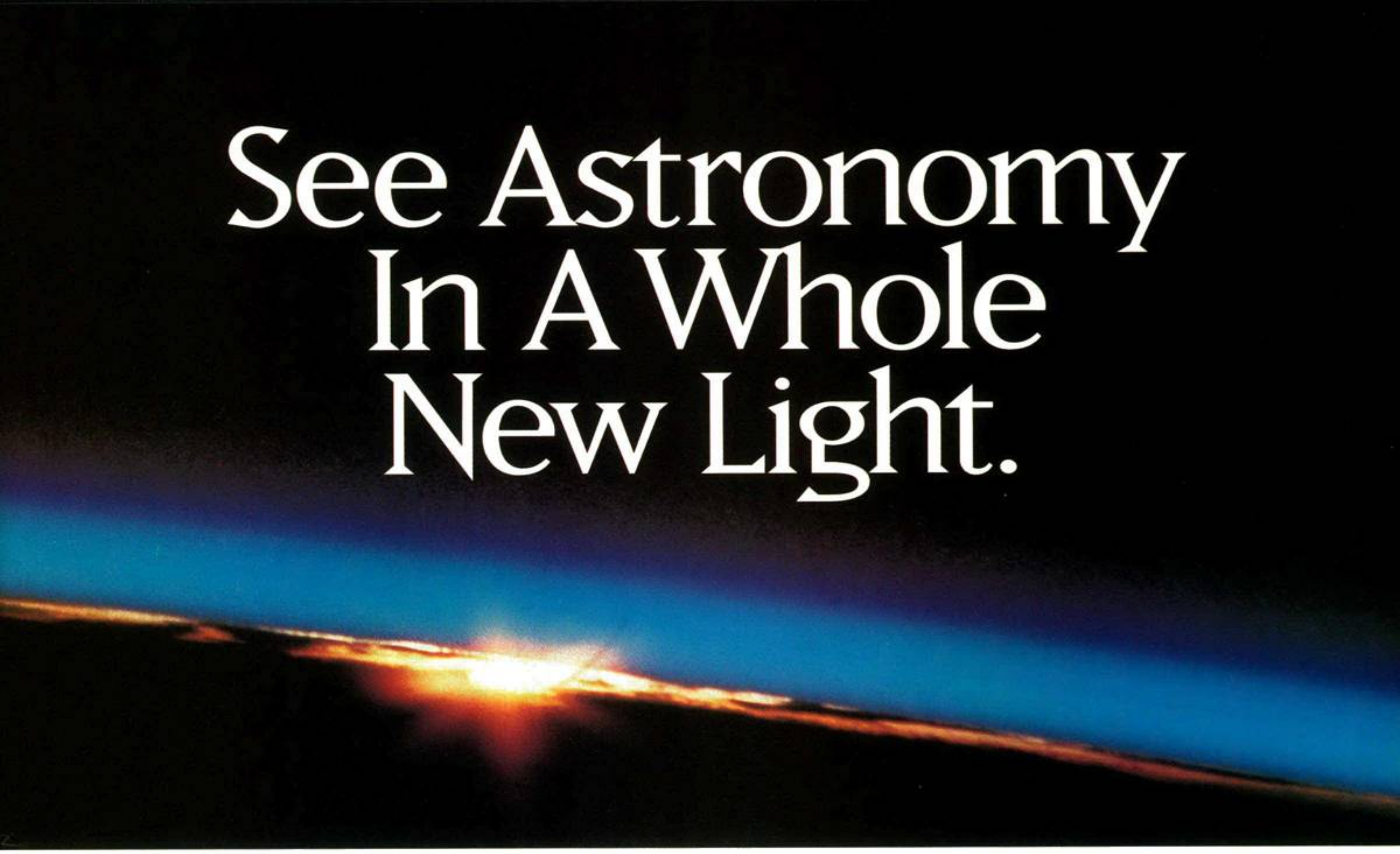

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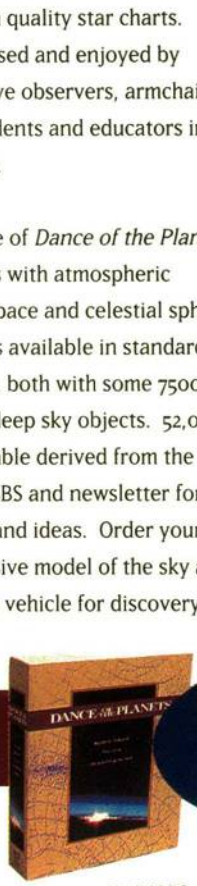

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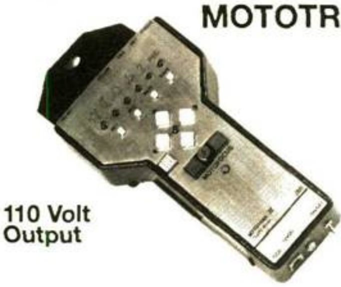

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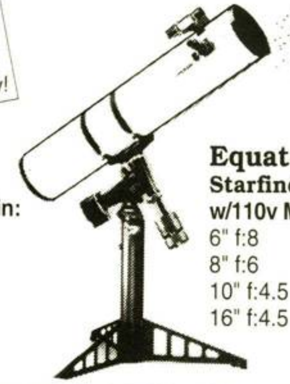

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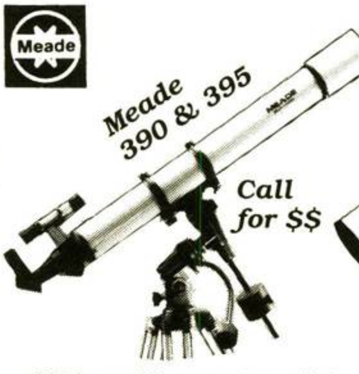

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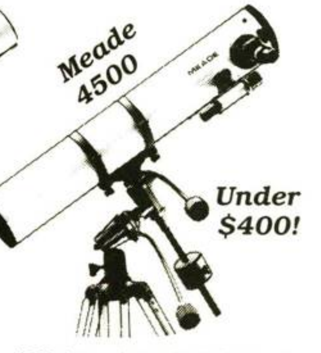

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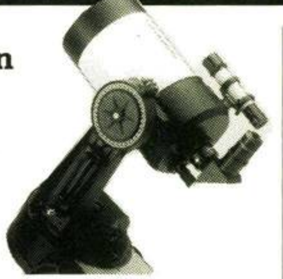

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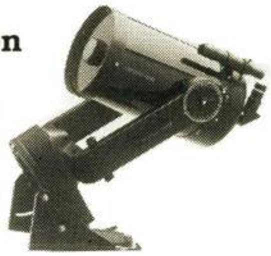

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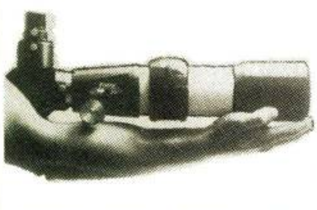

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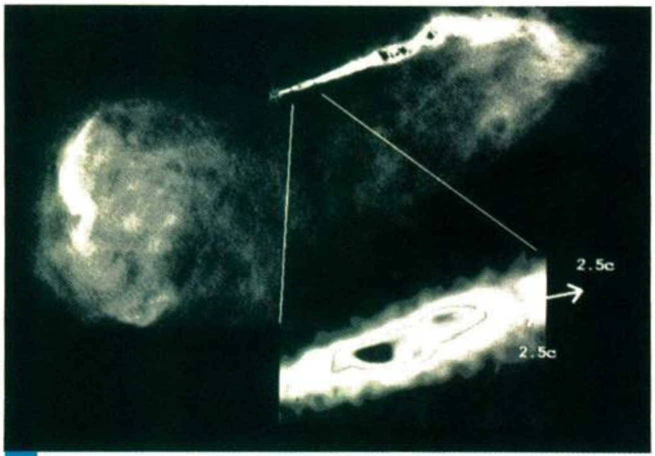


John Biretta, STScI

A JET 16,000 LIGHT-YEARS LONG MARKS the turbulent trail of material escaping from M87's center at velocities approaching the speed of light, as imaged by the VLA radio telescope. Some areas of the jet are moving toward Earth, giving the illusion that they are moving at twice the speed of light.

direction, yet this faster-than-light effect is still detected. Biretta speculates that some material in M87's turbulent stream is moving directly toward Earth, enough to contribute to a measure of superluminal motion.

What's speeding up this material to begin with? A very powerful "central engine" in M87, most likely a supermassive black hole. "Finding superluminal velocities further supports the existence of a massive black hole at the center (see AstroNews, September 1994), since few other objects could accelerate material to such speeds," remarks Biretta.

Clementine's Images On-Line

Nearly two million images from the Clementine mission to the Moon are now available via the Internet. The U.S. Naval Research Laboratory has opened the entire collection of images from the mission — 1.8 million images in all — to the general public.

Anyone with Internet access can reach the image files through the World Wide Web from the laboratory's home page. The address is http://www.nrl.navy.mil. Send e-mail questions or comments to webmaster@nrl.navy.mil.

Another Comet Goes to Pieces

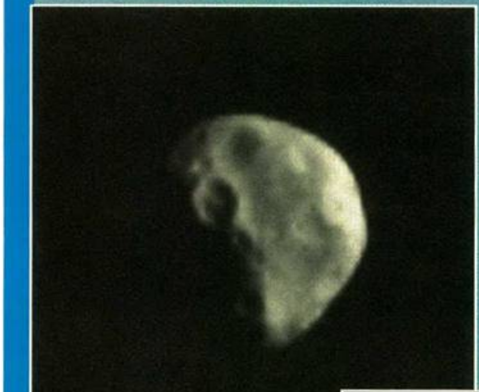
Just weeks after Comet Shoemaker-Levy 9's 23 major fragments smashed into Jupiter's cloudtops, amateur astronomer Don Machholz found another comet that appears in pieces.

Designated Comet Machholz 2 (1994o), the comet was discovered on August 13, 1994, with a 10-inch telescope from Machholz's backyard in Colfax, California. Reportedly a 10th-magnitude object at discovery, observers gauged it two magnitudes brighter than that.

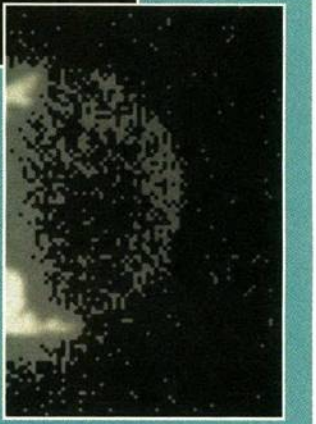
And then came the surprise. On August 28 Austrian astronomer Michael Jager found a second comet about two magnitudes fainter than 1994o some 48' northeast and moving in tandem.

On September 3 two observers reported a third cometary object in the field. Three days later several observers reported a fourth and fifth fragment in the field. At press time the comet consisted of five pieces, but it's likely more will be found. In early September the third fragment was 43" southwest of fragment two. The fourth fragment lay 320" and the fifth fragment 307" north-northwest of the main comet.

The fragmented Comet Machholz 2 reached perihelion, its closest point to the Sun, on September 18. It will slowly fade but remain visible in the morning sky throughout the autumn before shifting into the evening sky next spring. Epoch 2000 positions follow: 10h30.8m, 1°36' (Nov. 1); 11h13.3m, –8°51' (Dec. 1); 11h22.8m, –15°11' (Jan. 1, 1995); and 10h56.0m, –16°47' (Feb. 1).



NASA/JPL



Rock Moonlet or Rubble Pile?

The tiny moon of asteroid Ida, officially named Dactyl in September, is remarkably round for a rocky body only a mile in diameter (above). So some scientists are speculating that Dactyl may be a relatively loose collection of rocks and boulders held together by gravity. A solid-rock moon, they feel, would likely be much more irregular.

Another image (above right), caught just at the edge of Galileo's camera frame, shows a shadowed part of the moonlet faintly lit by "Ida-shine." A mile-deep valley (top) crosses Ida's middle in this, the highest-resolution photo taken of any asteroid; each pixel covers about 80 feet on the surface of Ida.

One Star Cluster Lost, Another Gained

Observing guidebooks describe the star cluster NGC 2451 in Puppis as moderately rich in stars, slightly condensed at the center, scattered around the star c Puppis, and located at a

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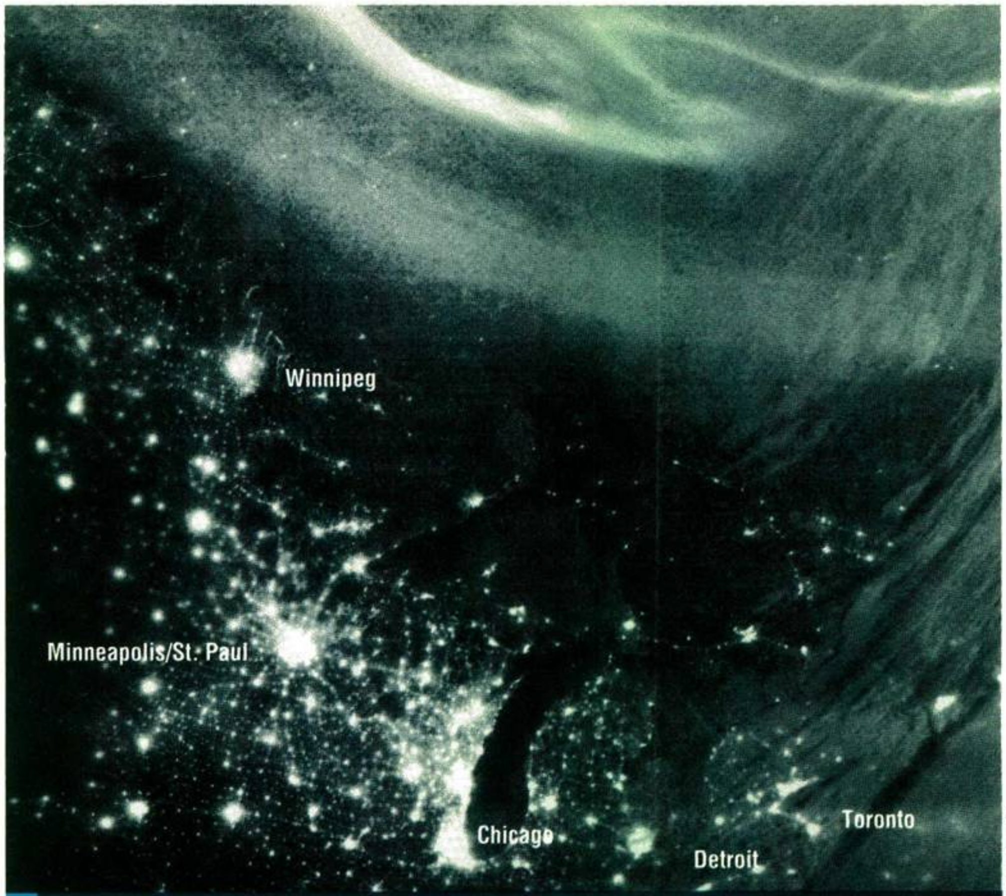
distance of 1,000 light-years. Now Siegfried Röser and Ulrich Bastian of the Astronomisches Rechen-Institut in Heidelberg, Germany, have shown that the stars do not form a gravitationally bound cluster but are, in fact, just a random grouping.

The astronomers studied the motions of the stars and showed that they do not share a common motion across the sky as a cluster would. So, as they report in the May (III) 1994 issue of *Astronomy and Astrophysics*, NGC 2451 is merely a chance alignment of stars appearing in the same region of Puppis.

The researchers, however, uncovered a cluster near but not related to NGC 2451 that they call the Puppis Moving Group. This collection of two dozen stars lies 700 light-years from Earth. The astronomers may have found a second cluster about 1,300 light-years away, but this fainter collection of stars will require additional observations to prove its existence.



Hank Brandli

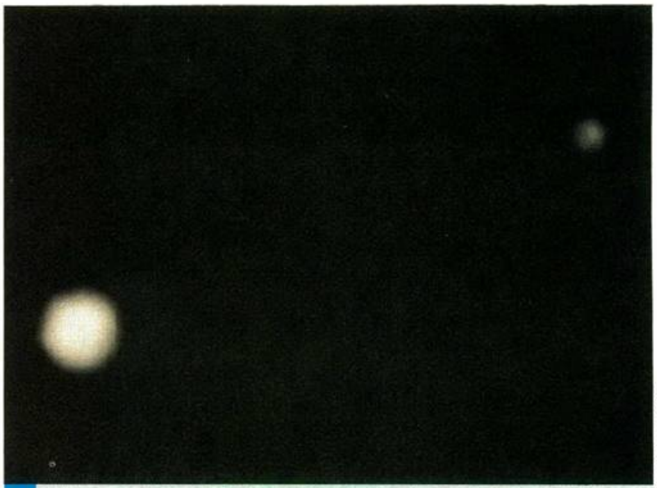
NORTHERN LIGHTS VIE WITH CITY LIGHTS in this satellite photo of the upper Midwest taken January 4, 1994. From an altitude of 450 miles, a DMSP weather satellite captured in visual light a low-latitude aurora (upper right) along with lights from cities in the North Central United States and South Central Canada. Clouds associated with a cold front (lower right) are illuminated by a crescent Moon.

Breaking the BL Lac

A three-day exposure last year using NASA's Extreme Ultraviolet Explorer satellite has landed the first absorption spectrum of a BL Lacertae object, energetic radio sources that are thought to bridge the evolutionary gap between quasars and galaxies. An absorption spectrum allows astronomers to pin down fundamental physical characteristics of these objects, such as their composition and temperature, and could verify whether BL Lac objects have jets. Across all wavelengths, from radio waves to gamma rays, the spectra of BL Lac objects appear smooth, devoid of any absorption features that might shed light on their nature.

Like quasars, BL Lac objects are believed to be powered by huge amounts of material that fell into an accretion disk surrounding a massive black hole. Some of the material falling into the accretion disk squirts into space as a beam of material that contains thousands of stars worth of matter. The new EUVE data could provide insights into how massive black holes create jets deep in the solar system-sized heart of these objects.

"The validity of a beaming model has been pretty well established, but without spectroscopy we couldn't really address the physics [within a BL Lac object]," says University of California at Berkeley astronomer Stuart Bowyer, principal investigator of the EUVE mission that obtained the spectra. "Now at last we've got what astronomers love more than anything . . . spectra."



ESA/NASA/STSc

THE CLEAREST VIEW YET — Pluto and its moon Charon show as separate bodies in this image taken with the Hubble Space Telescope's Faint Object Camera after the optical fix. Planetary scientists have now measured the diameters of Pluto (2,320 kilometers) and Charon (1,270 km) to about 1 percent. Scientists hope that future HST observations will let them map, at least crudely, the surface features of the pair.

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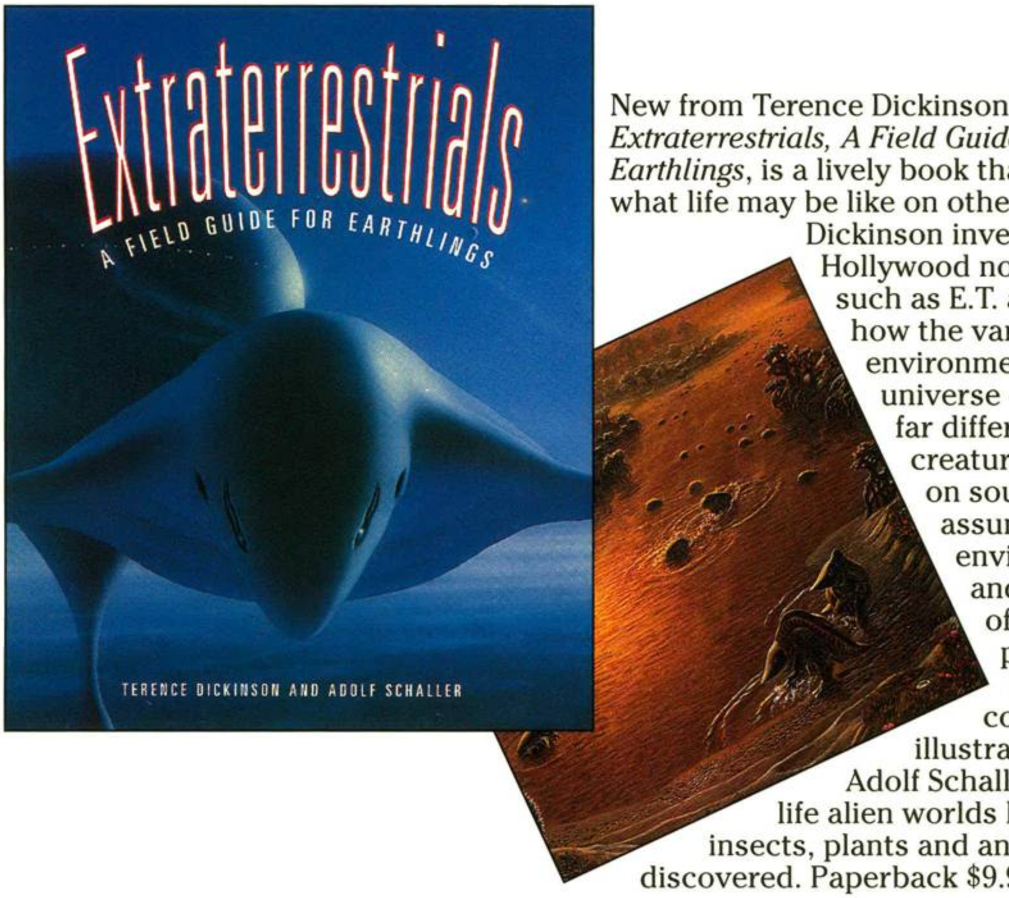
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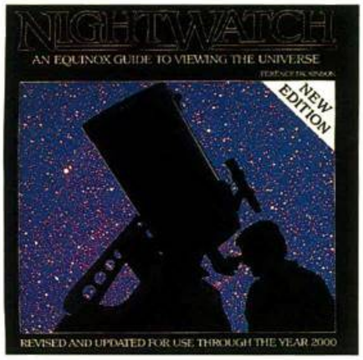
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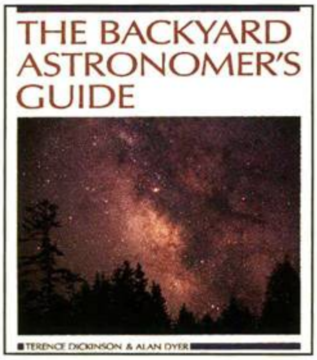
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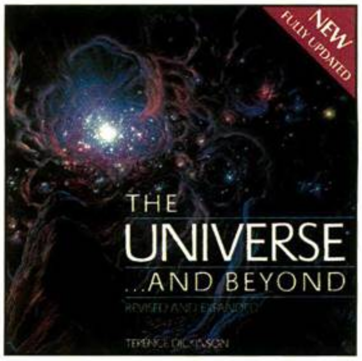
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Amateurs Gather in Vermont and Missouri

On August 5-7, 1994, more than 2,000 backyard astronomers converged on Breezy Hill in Springfield, Vermont, to enjoy the 59th annual Stellafane convention. A week earlier, about 250 observers and astrophotographers met in Kansas City, Missouri, in the Astronomical League's yearly ALCON meeting. Each meeting featured talks, workshops, telescope exhibits, and observing under clear skies.

The Kansas City meeting took place from July 28-31, on the campuses of Avila College and the University of Missouri. Workshops included presentations on planetary observing by José Olivarez, CCD imaging by Richard Berry, solar observing by Wally Piorkowski and Vic Winter, mirror grinding by Dan Joyce and Dan Troiani, observational tips by Barbara Wilson, and astrophotography by Jeff Peronto. Featured speakers included NASA's Lou Marshall, who updated attendees on the Hubble Space Telescope's latest research, and Wakefield Dort of the University of Kansas, who introduced the audience to Nebraska's Myrna meteor crater.

The hard work and generosity of librarians and astronomers at the University of Missouri provided ALCON participants a chance to see an outstanding collection of antique star maps and books. "Out of This World; the Golden Age of the Celestial Atlas," which premiered as an exhibition at the university's Linda Hall Library, contained dozens of first editions of rare atlases. Among the treasures on view were copies of Hyginus' *Poeticon astronomicon* (1482, the first printed book containing pictures of constellations), Johannes Bayer's *Uranometria* (1603), John Flamsteed's *Atlas coelestis* (1729), John Bevis' *Uranographia Britannica* (*ca.* 1750), and Johann Bode's *Uranographia* (1801).

ALCON attendees capped the weekend with a barbecue at Powell Observatory, southwest of Kansas City, at which they heard Jack Horkheimer, television's "Star Hustler," speak on comets. Afterward they wandered the field of telescopes and observed the prominent impact sites of Comet Shoemaker-Levy 9 on Jupiter's southern hemisphere. Particularly fine views were provided by the observatory's 30-inch f/5 reflector.

Such a wonderful outcome seemed a distant possibility for Stellafane. Hard rain soaked the New England landscape on Friday morning, but a cold front moved through Friday evening just as activities began, drying the skies overhead. A mirror grinding workshop on Friday afternoon put on by the Amateur Telescope Makers of Boston helped draw a record crowd. Friday night's informal tent talks centered on telescope making, reminiscences of May 10's annular eclipse, observations, and sustained excitement over observing the impacts of Shoemaker-Levy 9.

The formal talks on Saturday afternoon featured Pete Kandefer's experience as a Hubble Space Telescope amateur observer, John Dethoff's discussion of composite material as a means of building telescopes, and Peter Talmadge's encouraging presentation on how easy it is to build your own telescope.

On Saturday night the featured speaker was Robert Williams, director of the Space Telescope Science Institute, who updated the crowd on the latest and greatest results involving the comet crashes, the confirmation of a black hole in galaxy M87, and the ongoing research into the distance scale of the universe.

Saturday's routine was markedly different, however, as Stellafane's venerable institution, astronomy writer Scotty Houston, had died the previous December. His usual "shadowgram," a reflection on amateur astronomy and the Stellafane convention, was greatly missed. Instead, family members joined the more than 2,000 people on Breezy Hill in a candlelight memorial in Scotty's memory, "so that he might see us from above." ☐

ASTRONOMY: David J. Eicher

MORE THAN 2,000 CANDLES illuminated Breezy Hill in a memorial service for Walter Scott Houston, the beloved astronomy writer who died in December 1993.

Amateur Group Plans Comeback

Many amateur astronomers have heard of the International Astronomical Union (IAU), a group that serves as the governing body of professional astronomy. But how many are aware of the International Union of Amateur Astronomers, an organization the IAU helped to create 25 years ago? After its inception the IUAA never really caught on among backyard astronomers, especially in North America.

Last fall the long-dormant IUAA gathered at the University of Wolverhampton in England. Over 100 people from nine countries attended the week-long conference, which spotlighted efforts to foster international amateur activities. Besides sponsoring talks that covered everything from comet observing to video astronomy, organizers pushed for the IUAA's revitalization. To that end the organization's president, Vinicio Barocas, called for greater amateur support of IUAA initiatives in stimulating cooperation between amateurs worldwide and in building contacts with professional astronomers through the IAU.

Current plans call for general assemblies to be held every three years, hosted by different countries in conjunction with IAU General Assembly. The IUAA will publish updates on recent amateur activities in a quarterly newsletter called *Communications.* The organization also hopes to form an information bridge between amateurs in developed countries and those in poorer nations, who often work in isolation.

For more information on how the IUAA's efforts can be brought to North American shores, write John Perdrix, IAUU Secretary, P.O. Box 107, Wembly, Western Australia 6014, Australia. Corporate and individual annual membership costs $30 and $15, respectively. — *Donald Larson*

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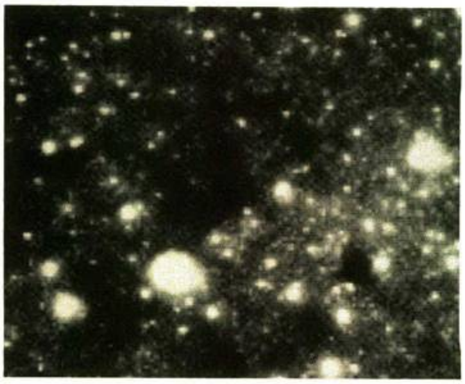

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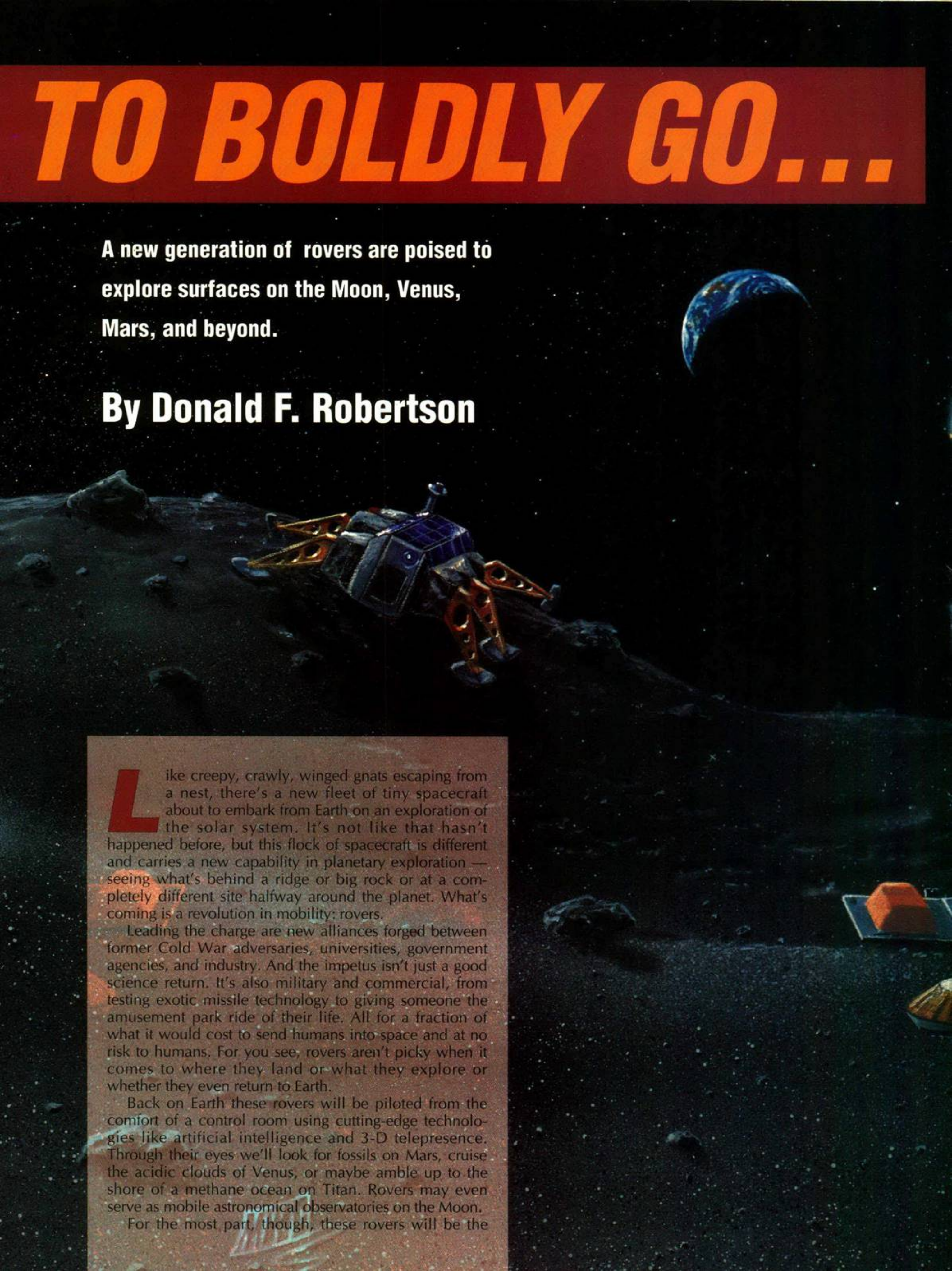
TO BOLDLY GO...

A new generation of rovers are poised to explore surfaces on the Moon, Venus, Mars, and beyond.

By Donald F. Robertson

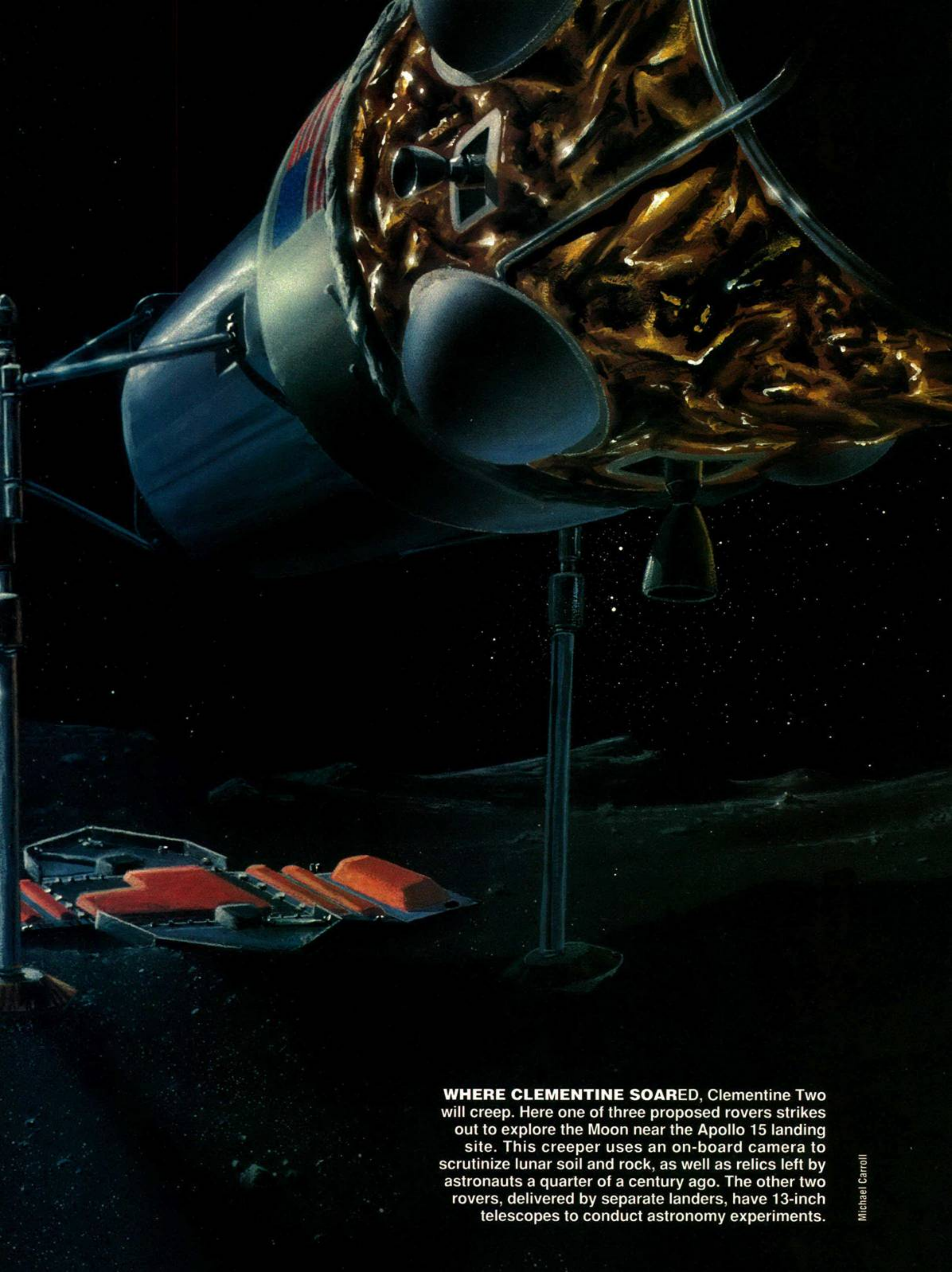


Like creepy, crawly, winged gnats escaping from a nest, there's a new fleet of tiny spacecraft about to embark from Earth on an exploration of the solar system. It's not like that hasn't happened before, but this flock of spacecraft is different and carries a new capability in planetary exploration — seeing what's behind a ridge or big rock or at a completely different site halfway around the planet. What's coming is a revolution in mobility: rovers.

Leading the charge are new alliances forged between former Cold War adversaries, universities, government agencies, and industry. And the impetus isn't just a good science return. It's also military and commercial, from testing exotic missile technology to giving someone the amusement park ride of their life. All for a fraction of what it would cost to send humans into space and at no risk to humans. For you see, rovers aren't picky when it comes to where they land or what they explore or whether they even return to Earth.

Back on Earth these rovers will be piloted from the comfort of a control room using cutting-edge technologies like artificial intelligence and 3-D telepresence. Through their eyes we'll look for fossils on Mars, cruise the acidic clouds of Venus, or maybe amble up to the shore of a methane ocean on Titan. Rovers may even serve as mobile astronomical observatories on the Moon.

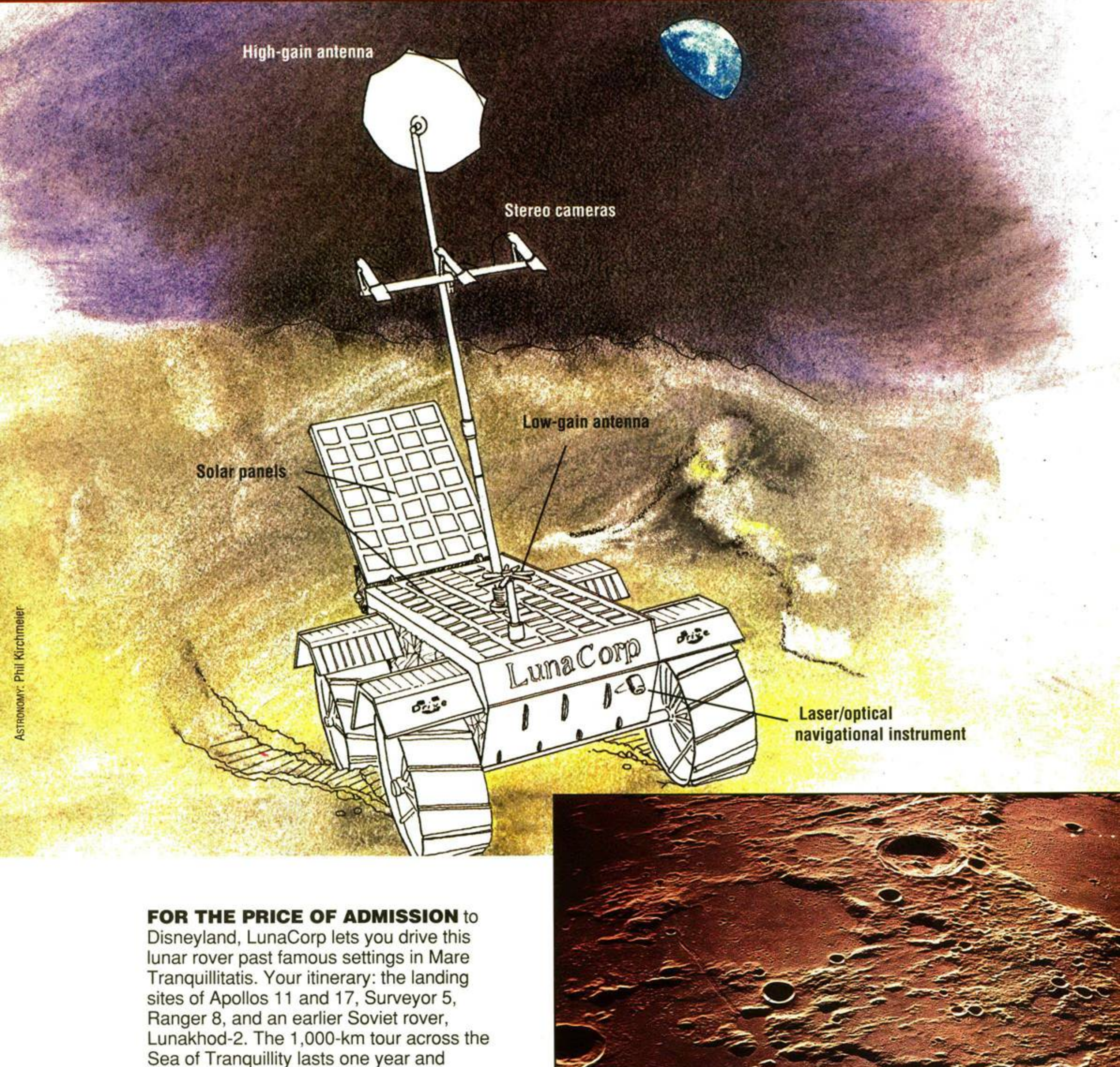
For the most part, though, these rovers will be the



WHERE CLEMENTINE SOARED, Clementine Two will creep. Here one of three proposed rovers strikes out to explore the Moon near the Apollo 15 landing site. This creeper uses an on-board camera to scrutinize lunar soil and rock, as well as relics left by astronauts a quarter of a century ago. The other two rovers, delivered by separate landers, have 13-inch telescopes to conduct astronomy experiments.

Michael Carroll

LunaCorp Lunar Rover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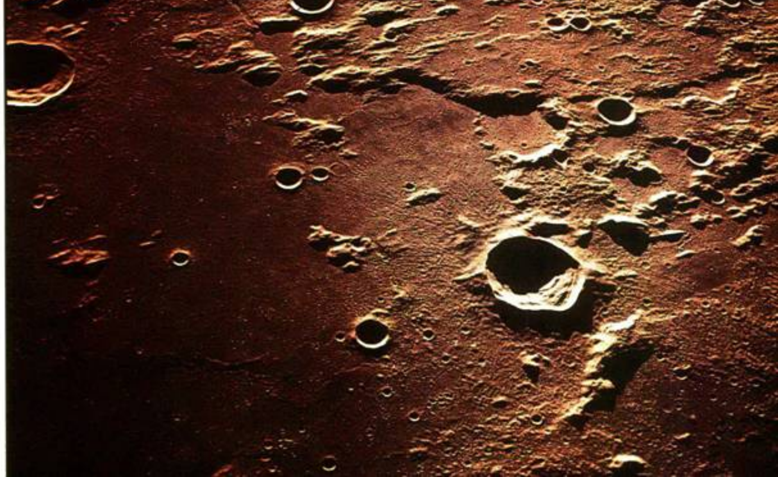
ASTRONOMY: Phil Kirchmeier



FOR THE PRICE OF ADMISSION to Disneyland, LunaCorp lets you drive this lunar rover past famous settings in Mare Tranquillitatis. Your itinerary: the landing sites of Apollos 11 and 17, Surveyor 5, Ranger 8, and an earlier Soviet rover, Lunakhod-2. The 1,000-km tour across the Sea of Tranquillity lasts one year and departs Earth in 1997.

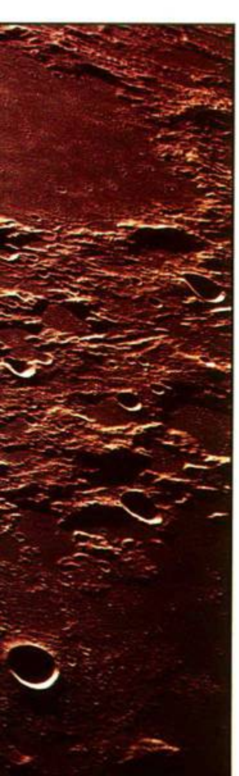
prototype for more sophisticated rovers to come. The technology is still under development, with some expertise coming from the most unlikeliest of places, like the Pentagon.

Cold Warriors crave extremely precise orientation in space. They need it to ram projectiles into nuclear warheads as part of a missile defense system. Now that the threat from warheads has diminished, the same Pentagon office that flew the successful Clementine mission to the Moon wants to make a deal with NASA: Use the technology derived from Star Wars test projectiles to land a rover on the lunar surface.

To prove the concept, the Ballistic Missile Defense Organization recently tested its proposed lunar landing system by setting up a simulated lunar surface and soft-landing a prototype lander on it. A battery-powered microrover, weighing just two pounds, was ejected from a tube on the lander and employed six spidery legs to crawl over the surface. A camera on the rover transmitted real-time pictures. While this exact rover design may not fly to the Moon, it did demonstrate what the BMDO team can deliver. The Department of Defense's proposal: They will provide the propulsion system to deliver a payload to the Moon if NASA funds a spacecraft and does some science.

"The bottom line," says Stuart Nozette, a Clementine manager at the Ballistic Missile Defense Organization, "is that we are looking for something challenging to do as a follow-up to Clementine, a mission that tests advanced, cutting-edge technologies. One of the technologies we have a large investment in is the Strategic Defense Initiative's light-weight propulsion system. We could not test that technology on the Clementine 1 mission. We've explored mission concepts that can test the technology and one is a lunar lander. Our test demonstrated to NASA that we could integrate a real lander with a real rover."

And NASA has noticed. The Jet Propulsion Laboratory now has a Clementine study office to work with the Pentagon on developing lunar missions using BMDO technology.



One idea involves delivering three rovers to the Apollo 15 landing site. Two of the rovers, dubbed Huey and Dewey after the Disney "Donald Duck" cartoon characters, will carry 13-inch telescopes that can operate as one big scope through a technique called interferometry. This method uses two or more widely separated telescopes and a lot of clever software to synthesize a "virtual" telescope with a diameter identical to the distance between the real telescopes. Because the telescopes are on rovers, the diameter of the virtual telescope can be varied depending on what astronomers want to study.

Using this lunar observatory on wheels, astronomer's propose conducting a relativity experiment. Right after the Sun sinks behind the Moon's horizon, a photograph would be taken of a star field in line with the Sun. Relativity predicts the Sun's gravity should slightly distort the relative positions of stars in the field. In the Moon's airless environment, it should be possible to measure with sub-arcsecond precision any distortion in the star field caused by the Sun's gravity.

While Huey and Dewey gaze heavenward, a third rover, Louie, will trundle closer to the Apollo 15 landing site and study artifacts left by astronauts. Engineers are interested in examining the effects of 25 years of exposure on the Apollo equipment.

While spacecraft designers would find such information useful, another rover effort has other reasons for visiting an Apollo landing site. A small private company called LunaCorp wants to sell a high-fidelity "walks" around Apollo 11's "Tranquility Base" to entertainment companies and theme parks. To accomplish this, LunaCorp has ordered a stripped-down lander built by the NPO Lavochkin Science and Production company in Russia and marketed by International Space Enterprises of San Diego. This lander would deliver LunaCorp's rover to the lunar surface.

After the 300 kg rover lands at the Apollo 11 landing site in the Sea of Tranquility, paying customers will drive it north to Surveyor V, over to the Ranger 8 impact site, and finally to the Apollo 17 site to end the mission in a spectacular mountain setting. From lunar shore to shore, the mission lasts one year, which, given the lunar nights, amounts to six months of actual driving time. During that time, LunaCorp engineers say the rover will traverse 600 to 1,000 kilometers.

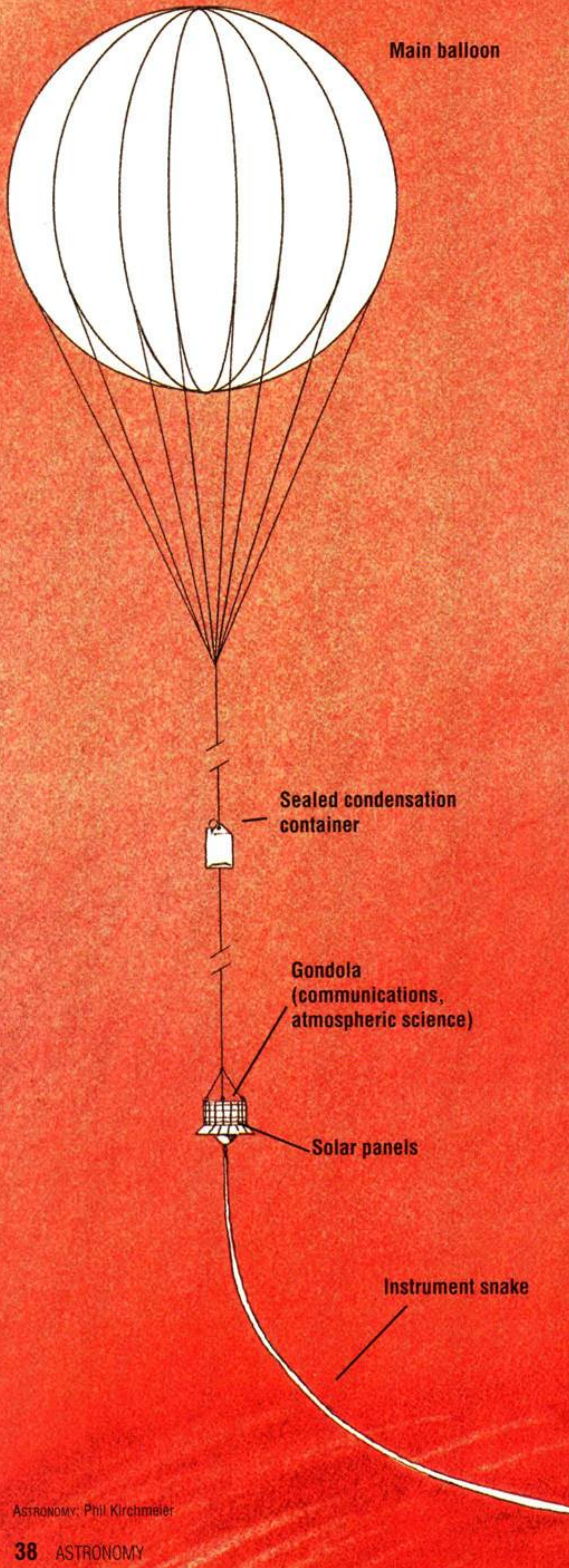
The rover is being designed by a group at Carnegie Mellon University that also built robots involved in the Three Mile Island and Chernobyl cleanups. It looks like a white bowling ball cut in half. The bottom, rounded half is attached to four wheels while the flat top supports the solar arrays. A single mast facing forward holds a stereo camera and a dish antenna pointed at Earth.

The estimated mission cost, says LunaCorp Director Rick Tumlinson, is $130 million. That money will pay for the first mission, a second lander, and insurance for a third. Tumlinson is upbeat that LunaCorp can raise the money, mentioning that $130 million is in the same ballpark as funding large entertainment events on Earth.

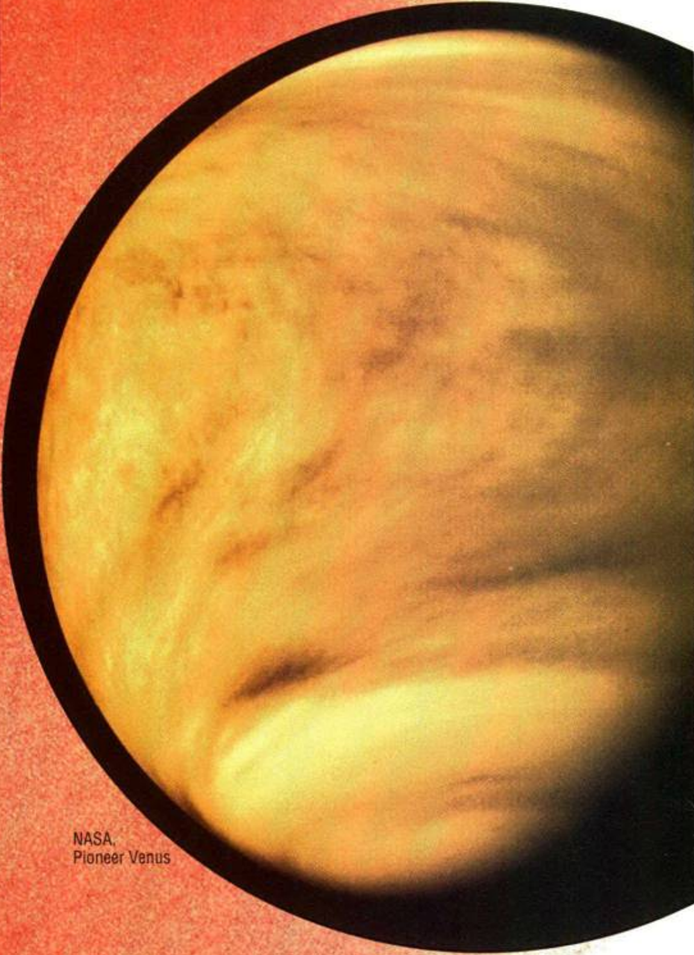
"We like to think we are being very practical," says Tumlinson. "We have a long-term strategy. We are trying to commercially fund exploration of the Moon in the same way that one might fund an Everest expedition. Space is a frontier and we believe that there is no crime in combining exploration with making a profit."

LunaCorp's commercial mission may be in for more competition than from BMDO/NASA spiders: NASA might buy its own Russian rover for a Discovery mission to Earth's Moon. The modified rover would serve as a test bed for telepresence technology. Stereo cameras on the rover will give Earth-bound operators wearing special viewing helmets the feeling of being on the lunar surface. As the controller turns his or her head, stereo cameras on the lander will pivot accordingly. Armed with such visual acuity, scientists will be able to gently reach out with a probe mounted on the rover's arm and touch a rock or patch of soil to determine its composition. Through the information superhighway, thousands of students around the country will use their own classroom 3-D viewscreens to poke and prod along with investigators.

Venus Flyer


Main balloon
Sealed condensation container
Gondola (communications, atmospheric science)
Solar panels
Instrument snake

ASTRONOMY: Phil Kirchmeier



NASA,
Pioneer Venus

THE VENUS FLYER DIPS through sulfuric acid clouds to reach Venus' surface, where temperatures are 450° C and the air pressure is 90-times that on Earth. Instruments mounted on a "snake" gather information about the Venusian soil. Cameras in the gondola record the hellish scene. After spending about an hour on the ground, the Flyer rises 30 miles skyward to cool off, recharge its batteries with solar panels, and transmit data to Earth. Venusian winds carry the probe to different locales.

If there is one place where rover telepresence technology might prove to be very useful, it's on Venus. It's likely humans will never walk on its surface. The planet's super-hot (450° C), super-corrosive atmosphere (complete with sulfuric acid clouds) forces designers to think twice about even placing a spacecraft on the surface. For one, a machine is being sent to a hellish world where lead can only exist in liquid form. Under such harsh conditions, lubricants in motors cease to lubricate and delicate electronic components run the risk of being destroyed. The longest any lander has ever survived on the plains of Venus is about 90 minutes. For Venus, engineers are quite literally designing a roving explorer from the inside out and thinking rather unconventionally.

"Planners have talked about making super-high-temperature solid state devices out of silicon carbide and diamond and ruby. There have been components made — but nobody's even built a radio," says Kerry Nock, manager of JPL's Advanced In Situ Exploration Systems. Even with heat-resistent electronics, Venus' heat would slowly sap the spacecraft's strength. Insulating a rover for more than a few hours is difficult and expensive. If some sort of refrigeration system is applied, most of the rover's power goes to try to keep things cool, leaving little to run the rover or do the science. Worse, the electronics and refrigeration equipment would generate their own heat, which also has to be removed.

But what if you could occasionally immerse the rover in a cold environment, letting it get rid of accumulated heat? Great idea. But where on Venus is there a cold environment? In Venus' upper atmosphere, reachable by balloon.

"If we could somehow operate in the atmosphere," says Nock, "we could cool the electronics. Periodically we'd lift up to 60 kilometers where the temperatures and pressures are more like Earth's. In the cloud tops, we could even use solar cells to generate electricity." By varying a balloon's buoyancy a science payload could get very close to the surface, and even land, providing much of the science that a surface-based rover could get. Nock's proposed mission is called the Venus Flyer.

Unlike a dedicated surface vehicle, the Venus Flyer could last for a long time and cover the entire planet. Venus' winds at high altitudes blow primarily from east to west and travel so fast they would carry the balloon around the planet in just six to eight Earth days. Winds at lower altitudes go north and south at a slower speed. By using the different wind patterns at different altitudes, a balloon could navigate over large areas of the Venusian surface and land at a specified location.

How would such a balloon work? Engineers want to avoid disposable ballast because conventional buoyancy gases would be used up quickly and end the mission. Russian and French scientists have studied balloons that use a "reversible fluid" like water. A reversible fluid allows the balloon to be a completely closed system and last indefinitely.

"Think of a water balloon," says Nock. "Below forty-two kilometers, as Venus' super-heated air gets hotter, that water vaporizes. The water vapor has a lower density than Venus' atmospheric carbon dioxide, which makes the balloon buoyant; it wants to go up. Past 42 km, at a pressure of 2.6 Earth atmospheres and a temperature of 130° C, water condenses back into a heavier liquid. This reduces buoyancy, so the balloon wants to go back down. Left alone, the balloon would oscillate up and down around this altitude."

But how do you get to the surface? JPL's design collects condensing water in a sealable container. This removes the balloon's capacity for buoyancy and allows it to go all the way to the surface. The balloon and gondola won't actually touch ground. Dangling from the gondola is a snakelike instrument stalk loaded with sensors that analyze soil and rock. Further up the stalk are cameras to photograph the surrounding terrain. After about an hour on the surface, water is released from the sealed vessel into the balloon, where it vaporizes in the high temperature. The balloon then rises up to the cooler, 42-km heights.

But even at 42 km, 130° C is hotter than it is safe to keep most electronics. Venus' cloud are also thick at this altitude; solar panels would find it difficult to generate electricity. The Venus Flyer needs to get even higher. The key? Using a reversible fluid both lighter than the carbon dioxide atmosphere and which condenses at 50 or 60 kilometers, where temperatures are cooler.

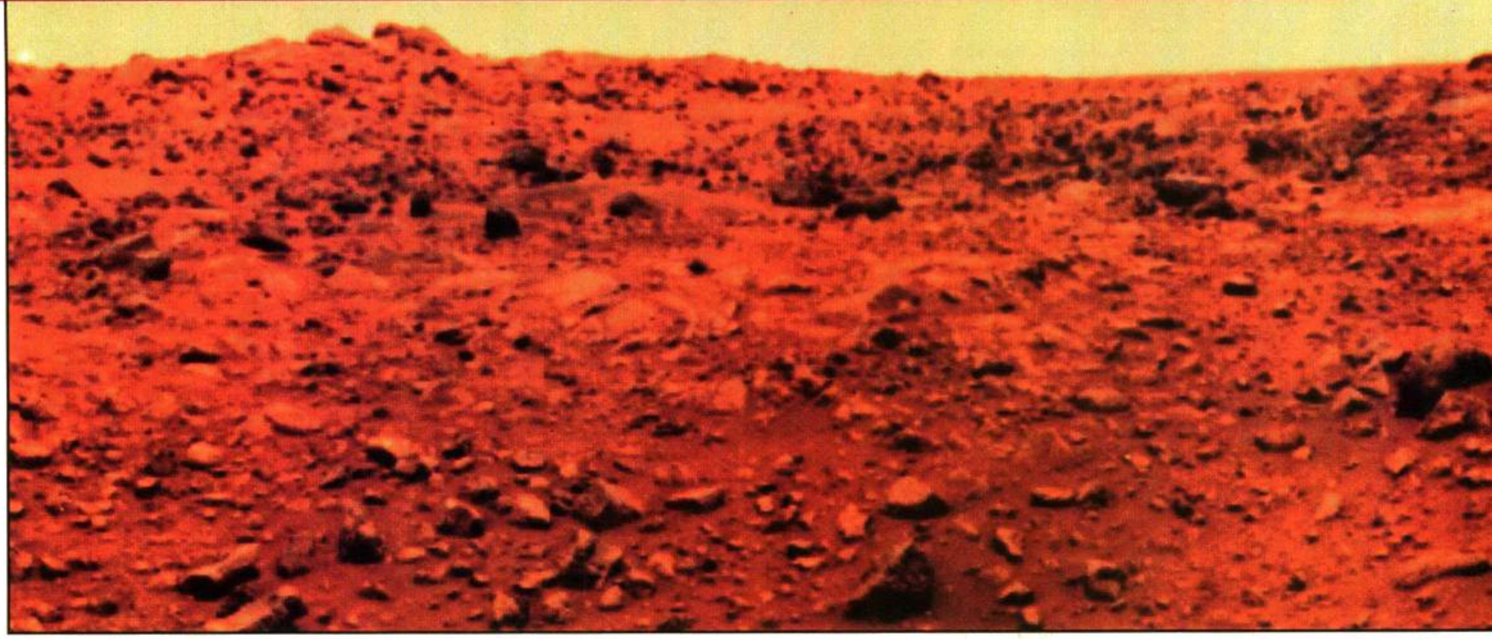
JPL engineers have found such a fluid in a mixture of hydrogen gas and water. When water vapor combines with hydrogen, most of the balloon's internal pressure is provided by the water vapor alone. So if half the volume of the balloon is water vapor and half hydrogen, the pressure of the water vapor in a given volume of the balloon is reduced to about half what it would normally be with water vapor alone. This hybrid vapor will not condense at 42 km, but much higher. How much higher depends on the amount of hydrogen in the mix. Water vapor diluted with hydrogen gas also condenses more slowly, so the balloon will "bounce" higher into the cooler (and scientifically more interesting) atmosphere before finally beginning to sink.

But there's no free lunch in this design: Because it is difficult to contain tiny hydrogen atoms, they will slowly seep from the balloon. The trade-off is limited mission lifetime. On the flip side, the technology is essentially proven. Since this balloon spends a good deal of its life at temperatures and pressures similar to those found on Earth, it is easy to test. JPL engineers are doing just that. "We have flown several experiments with free-flight passive balloons to characterize the physics and thermodynamics and aerodynamics of the system," says Nock.

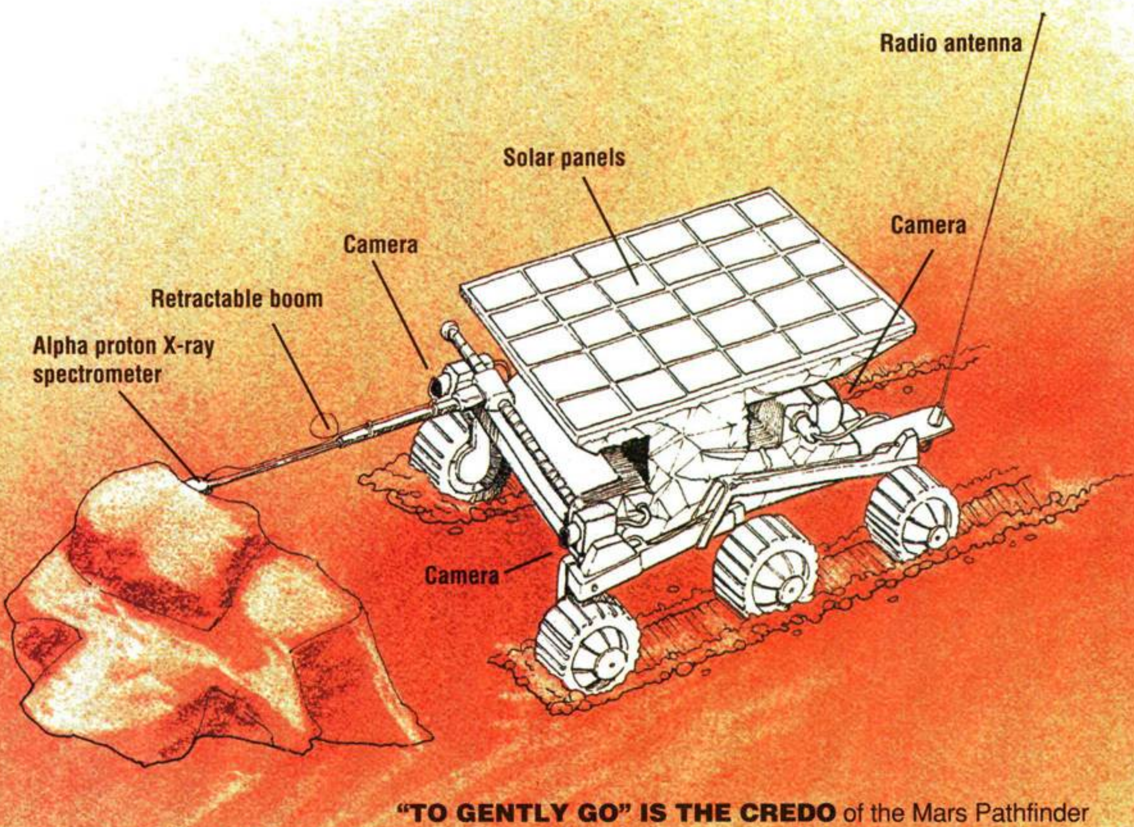
Mars is a long way from Venus, both in distance and planetary surface conditions. So a proposed Martian rover would appear very different from any cousin it might have on Venus.

Pathfinder rover looks like a tiny, disorganized stack of metal sticks on six wheels, covered by a sun hat. The sticks are an open girder suspension and the sun hat is a double panel of solar cells. It weighs just 10 kilograms and is only 68 centimeters long and 48 centimeters wide and 30 centimeters high. The six wheels can drive over an obstacle much larger than the diameter of the

Mars Pathfinder Rover



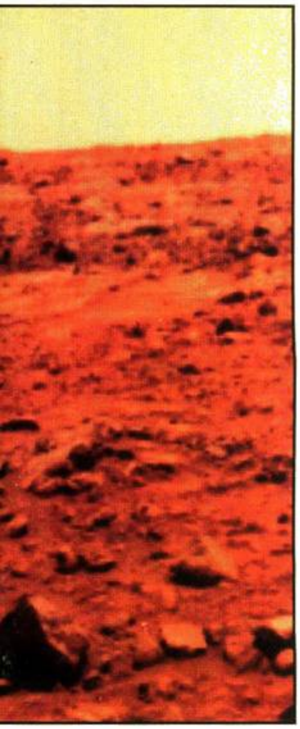
NASA, Viking 1



Radio antenna
Solar panels
Camera
Camera
Retractable boom
Alpha proton X-ray spectrometer
Camera

"TO GENTLY GO" IS THE CREDO of the Mars Pathfinder rover. Essentially an experiment itself, the rover tests technology for future Martian rovers and stays within a quarter-mile of its mother lander. Mounted on the rover are cameras that take close-up stereo photos of rocks and soil. A spectrometer mounted on the boom "tastes" the composition of anything it touches. Future variants of this rover will explore other areas of Mars or even the surface of Titan.

ASTRONOMY: Phil Kirchmeier



wheels, which a four-wheeled vehicle cannot do. "If you scaled it up to the size of a car," says an engineer, "you could drive it over a dining room table — slowly."

The Pathfinder microrover experiment is scheduled to be launched in December 1996 and delivered to the Martian surface via a lander on July 4, 1997. JPL is spending just $25 million to build and fly this first of what NASA hopes will be many Martian microrovers. For the Pathfinder mission, however, the rover is an experiment itself — in technology.

"This rover could not have been made twenty years ago," says Donna Shirley, team leader for the Pathfinder microrover experiment. "Extremely small electronics and high-powered motors the size of an A-cell battery just didn't exist twenty years ago."

Pathfinder rover also uses other technologies not available 20 years ago, including the latest in computer-assisted navigation coupled with lasers. Engineers at MIT and JPL have developed a unique method of piloting the rover, partially getting around the long time it takes radio signals to get to and from the rover to Earth. It is modeled after the way insects navigate.

"Insects kind of plunk along. They just walk in one direction until they encounter an obstacle and then they change the gait to get around the obstacle," says Shirley. "They don't have to understand the obstacle to avoid it. They just keep trying to get around the obstacle until something works and then they go back to what they were doing before."

The rover works much the same way. All the rover knows is its destination's coordinates as determined by an operator on Earth. Microrover uses a gyroscopic compass, an accelerometer, a running count of wheel rotations, and a laser to navigate around pitfalls without immediate help from Earth.

Five lasers project vertical planes of light ahead of the rover. These planes of light extend from the sky to the ground. Where a plane of laser light hits the ground, there is a bright line or stripe of light. If the ground is flat, the line of light is straight. If there is a rock or hole, the line of light wrinkles up or down, and sensors see a distortion. Depending on the distortion's position in a sensor's field of view, the rover can tell whether the obstacle is higher than its belly or represents a cliff or deep hole. After avoiding such a hazard the microrover automatically returns to the course needed to reach its destination.

This destination is preprogrammed from Earth at the start of each Martian day, when the rover's parent lander takes a stereo picture and radios it to Earth. Back home at JPL, the stereo image is displayed on a computer monitor where an operator examines it through special goggles. The "driver" sees a full three-dimensional image of the Martian surface and uses a computer mouse to move an icon representing the rover to an area mission scientists want to explore. With a click of the mouse, the destination's coordinates are calculated by computer and radioed to the microrover. Once the rover ambles to the desired spot, a handful of instruments are brought to bear on the target.

To visually scrutinize soil and rock, the microrover has three cameras, two facing forward and one back. "We'll be able to get images with the resolution needed to see large crystals," says Shirley. The rover also has an alpha-proton X-ray spectrometer mounted on the end of a tiny boom, which determines a rock's chemical composition. "The rover puts the boom up against a rock and it sits there for about 10 hours bombarding the rock with alpha particles, reading the spectrum of the elements sputtered off the rock," says Shirley.

At the end of a Martian day of prospecting, a photo from the lander determines if the rover has reached its destination. If not, the microrover's internal coordinates are reset from Earth to match reality, and the whole process starts again the next day.

The Pathfinder microrover travels extremely slowly and not very far. The range of the microrover's radio keeps it within 500 meters of its parent lander. And the rover can operate only when the Sun is high above the horizon, warming the electronics and providing energy to its on-board solar array. The rover "sleeps" during the cold desert nights. No overriding scientific ambition here, just a techno-test drive.

Once the Pathfinder microrover technology is proven, NASA plans to use the design in its Mars Surveyor program, which will see a fleet of orbiters and landers launched toward the Red Planet between 1998 and 2003. Surveyor micorovers will trek over greater distances because there will be a spacecraft in orbit to relay communications. The landers will also carry more ambitious, scientifically interesting instruments. One payload under consideration is a microscope camera designed by Czech scientists that would look for microfossils.

Can all this new microrover technology be used anywhere else in the solar system? "Right now, in order to work at other places besides Mars, we'd have to come up with improved thermal protection for the electronics and improved power generation," says Shirley. Saturn's giant moon Titan, bigger than planet Mercury, with possible water-ice continents in a methane ocean, cries out for exploration. "If the European Huygens probe on the Cassini mission to Saturn finds that there is some dry land, or at least 'dry ice,' on Titan," she says, "then we could consider sending rovers to it. And if we go to Titan, why not other outer planet moons?"

Such is the inevitability of rovers to other worlds. Means are being developed to extend human senses out to every planetary surface in the solar system. How will it be done? Take your pick: through a consortium of private investors or through military engineers or through the planetary sciences at JPL. The only certainty is that roving the planets by proxy will happen in our lifetime.

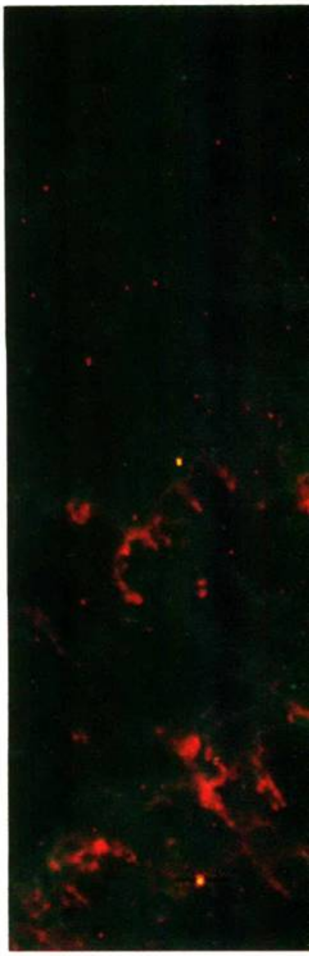
The rovers are coming. ☐

Donald F. Robertson is a science writer based in the San Francisco area. His last ASTRONOMY *article was "Return to the Moon?" (May 1994 issue).*

Inside the Crab Nebula

New Hubble images of this supernova remnant reveal a chaotic region of filaments and jets.

by Richard Talcott



Six thousand light-years away in the constellation Taurus lies an extraordinary object known as the Crab Nebula. The tattered remains of a star that went supernova in the year 1054, the Crab is a maelstrom of high-energy particles and radiation powered by a pulsar — the ultradense, rapidly spinning core of the exploded star that lies at the heart of the nebula.

For over two centuries, astronomers have intently observed this supernova remnant, making it one of the best studied objects in the sky. Yet new images taken by Jeff Hester and Paul Scowen of Arizona State University in Tempe using the Hubble Space Telescope's Wide Field/Planetary Camera 2 (WF/PC 2) show details in the Crab that astronomers never expected.

First, the Crab's filaments (opposite page) — gaseous material, or ejecta, cast from the exploding star at speeds of thousands of kilometers per second — appear far more complex and varied than previously thought. Some change properties along their lengths while others seem to contain both hot and cool gas in the same regions. The filaments also intermix with isolated knots of hot, warm, and cool gas. (In this false-color image, red denotes light emitted by oxygen atoms in cool gas, green indicates light from oxygen atoms in hot gas, and blue represents light from sulfur atoms in warm gas.) Earlier, lower-resolution observations from the ground smoothed over much of the structure actually present in the Crab.

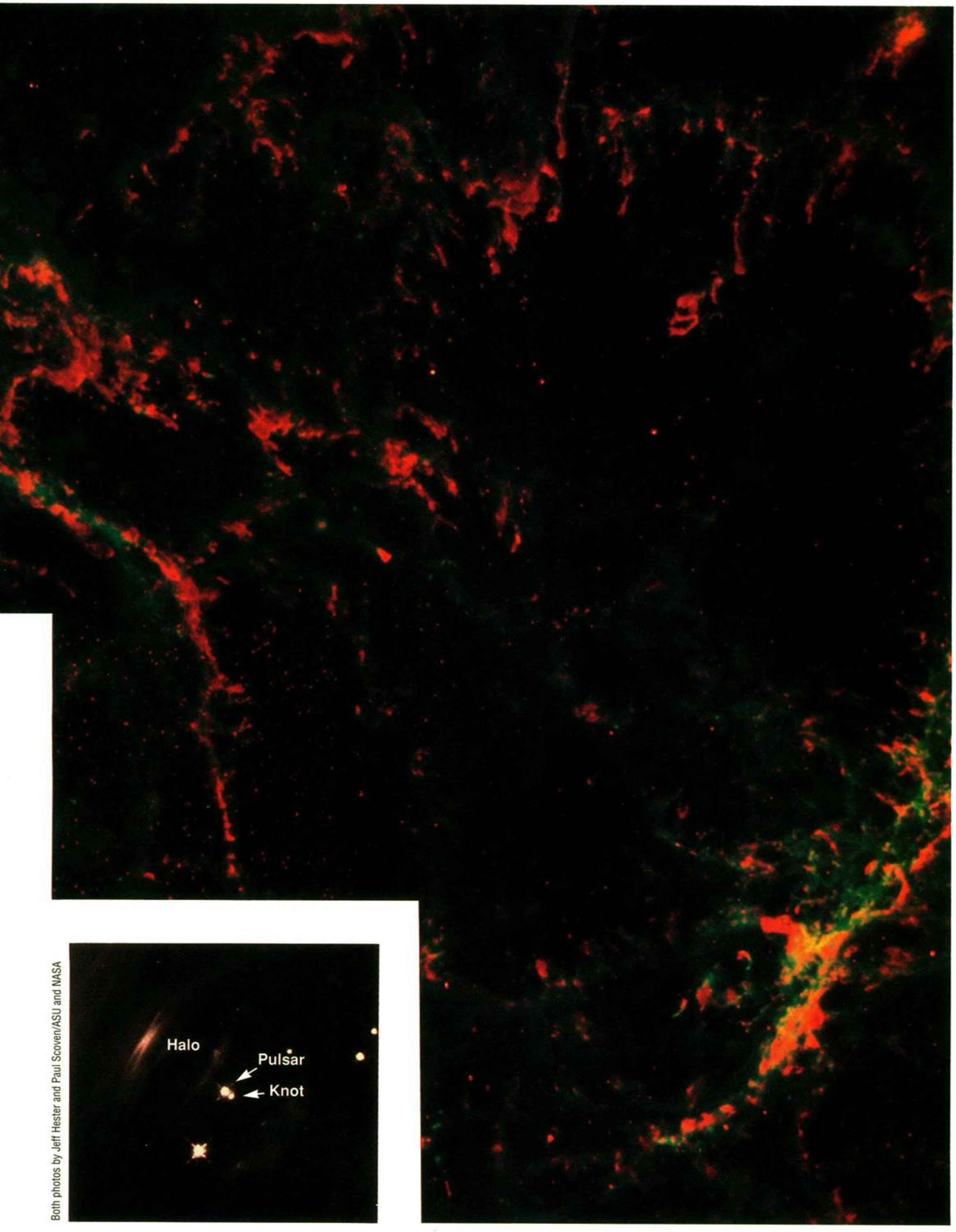
Second, Hester and Scowen found far more dust spread throughout the Crab than expected. Astronomers previously thought conditions in the nebula were too extreme for much dust to form. The dust resides in regions of very cool molecular gas and is easiest to spot by looking for dark patches superimposed against a bright background.

Third and perhaps most significantly, the researchers discovered how the filaments interact with the Crab's synchrotron nebula — the sea of magnetic fields and energetic particles that permeate the Crab. Hubble data show that the pressure of the synchrotron nebula largely determines the structure of the Crab filaments. The situation is analogous to a bottle of oil and vinegar salad dressing. When left to stand, the heavier vinegar settles to the bottom while the lighter oil rises to the top. If the bottle is then turned over, the denser vinegar breaks into many blobs that sink through the oil. In the Crab's case, the "light" synchrotron nebula tries to push the "heavy" ejecta, which break into cool, dense clumps that the synchrotron nebula flows around. Note the many examples throughout the Crab where long, fingerlike filaments with especially dense globules at their ends (shown in red) poke into the nebula's interior.

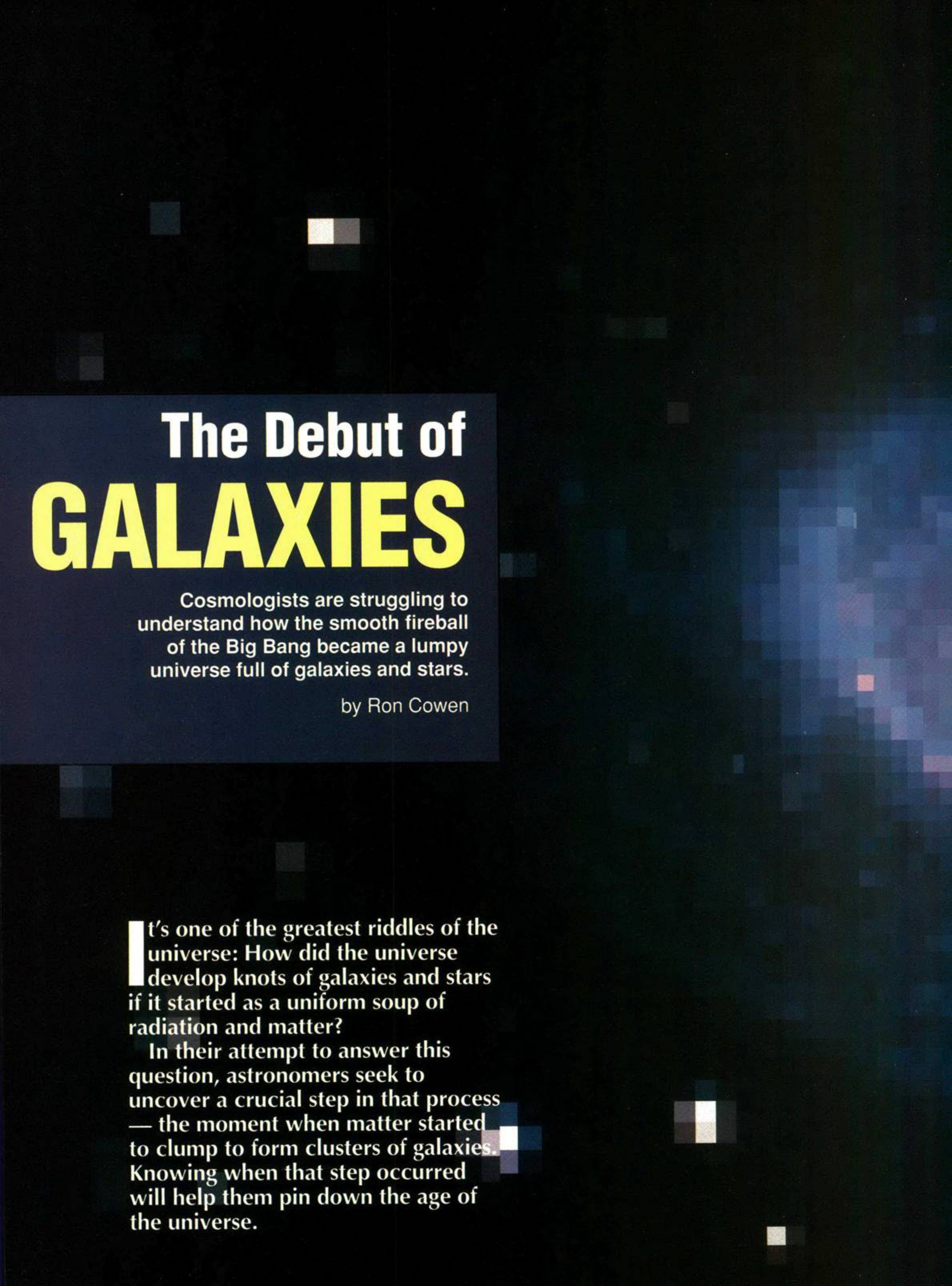
Much closer to the heart of the Crab, Hester and Scowen have helped clarify how the pulsar interacts with its environment (lower right). A second WF/PC 2 image reveals for the first time a small knot of bright emission just 1,500 astronomical units from the pulsar (1 AU is the average distance of Earth from the Sun). The knot and pulsar line up with an energetic jet of X rays that appears to lie along the pulsar's rotation axis. Hester and Scowen think that the knot may be a "shock" in the jet — a place where the wind streaming from the pole of the pulsar piles up.

Lick Observatory

The researchers also discovered a halo of emission tipped about 20° to our line of sight and located about 10,000 AU above the opposite pole of the pulsar. The X-ray jet flows right through the center of the halo. The ring may mark the boundary between regions dominated by the pulsar's polar and equatorial winds. But why there is a knot above one pole and a halo above the other is not clear. Still, as Paul Scowen says, "The new data have provided a clearer glimpse at the pulsar environment, a glimpse that should have theoretical astronomers scratching their heads for some time to come." □


Halo
Pulsar
Knot

Both photos by Jeff Hester and Paul Scoven/ASU and NASA



The Debut of GALAXIES

Cosmologists are struggling to understand how the smooth fireball of the Big Bang became a lumpy universe full of galaxies and stars.

by Ron Cowen

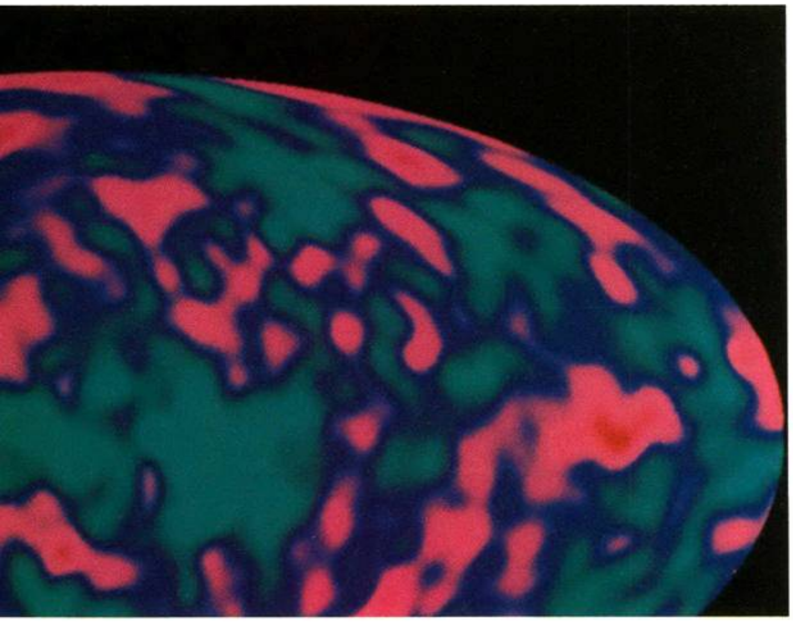
It's one of the greatest riddles of the universe: How did the universe develop knots of galaxies and stars if it started as a uniform soup of radiation and matter?

In their attempt to answer this question, astronomers seek to uncover a crucial step in that process — the moment when matter started to clump to form clusters of galaxies. Knowing when that step occurred will help them pin down the age of the universe.

Original image of M81 by Tony and Daphne Hallas

"We are pretty confused," says University of Hawaii astronomer Lennox Cowie, who surveys distant reaches of the heavens in the infrared part of the spectrum. The evidence for when galaxies formed, he says, seems to point in two different directions.

On the one hand, explains Cowie, observations of distant quasars indicate that galaxies and galaxy clusters developed in the universe soon after its explosive birth. Some of these quasars are so far away that the light they emit took some 13 billion years to reach us. In other words, these luminous powerhouses have been around for at least 13 billion years, and had already formed when the universe was less than 10 percent its current age of 15 billion years. Moreover, astronomers believe that quasars reside at the centers of galaxies. Thus, it would seem the core of galaxies that play host to quasars must have formed even earlier.



NASA/Goddard Space Flight Center

THE SEEDS OF STRUCTURE APPEAR in the cosmic background radiation. In 1992, the Cosmic Background Explorer satellite discovered tiny (0.001 percent) fluctuations in the radiation. The patchiness in this image is primarily due to instrumental noise.

But on the other hand, recent observations indicate that some galaxies took their final form relatively late. Cowie notes, "We now understand that a lot of evolution occurs in galaxies [long after they formed]. Since the time when the universe was half its current age, galaxies have changed their properties considerably."

Cowie's infrared studies reveal that when the universe was about half its current age, it contained three to four times as many dim, dwarf galaxies as the present. What happened to the dwarfs? They may have pulled a vanishing act, fading away until they could no longer be detected. Or, says Cowie, the dwarfs may be the building blocks for bigger galaxies, merging to form the array of galaxies typical of the Milky Way and its neighbors.

Recent images of individual galaxies taken with the repaired Hubble Space Telescope also reveal a higher density of wispy, faint galaxies in the past, notes Richard Ellis of the University of Cambridge in England. Ellis and Richard Griffiths of the Space Telescope Science Institute in Baltimore, Maryland, survey random patches of the sky with Hubble's second generation Wide Field and Planetary Camera when another instrument on the telescope is observing a particular target. That strategy, which produces fresh images each week, doesn't permit the researchers to obtain the spectrum of any of the galaxies. As Edwin Hubble showed in 1929, the shift of spectral lines to redder wavelengths is proportional to the distance of the galaxy.

Without spectra, Ellis and Griffiths can't measure the distance of their galaxies. But comparing ground-based images of galaxies of similar faintness with those of the more than 200 dim galaxies seen by the Hubble Space Telescope suggests they probably lie at a redshift of about one (the number indicates how many times their original wavelength the lines have shifted; a redshift of one corresponds to a distance of 9.8 billion light-years).

"Most of the galaxies that we see around us [today] have been around for a long, long time," Ellis says. But, he adds, even out at moderate redshifts, some galaxies "have undergone significant changes."

Not one, but several episodes of galaxy formation and evolution may in fact mark the transition from a smooth, primordial universe to the present-day lumpy one. In 1988, Princeton University cosmologist P. J. E. Peebles proposed that the universe got its lumps gradually, over several epochs.

The inner cores of galaxies appear to have formed first. These "spheroidal bulges" may have developed into elliptical galaxies, which basically consist of a compact bulge with no disk or spiral structure surrounding it. Many ellipticals do seem to rank as the senior citizens of galaxies: They contain little gas — the raw material for making new stars — and have lots of old, red stars.

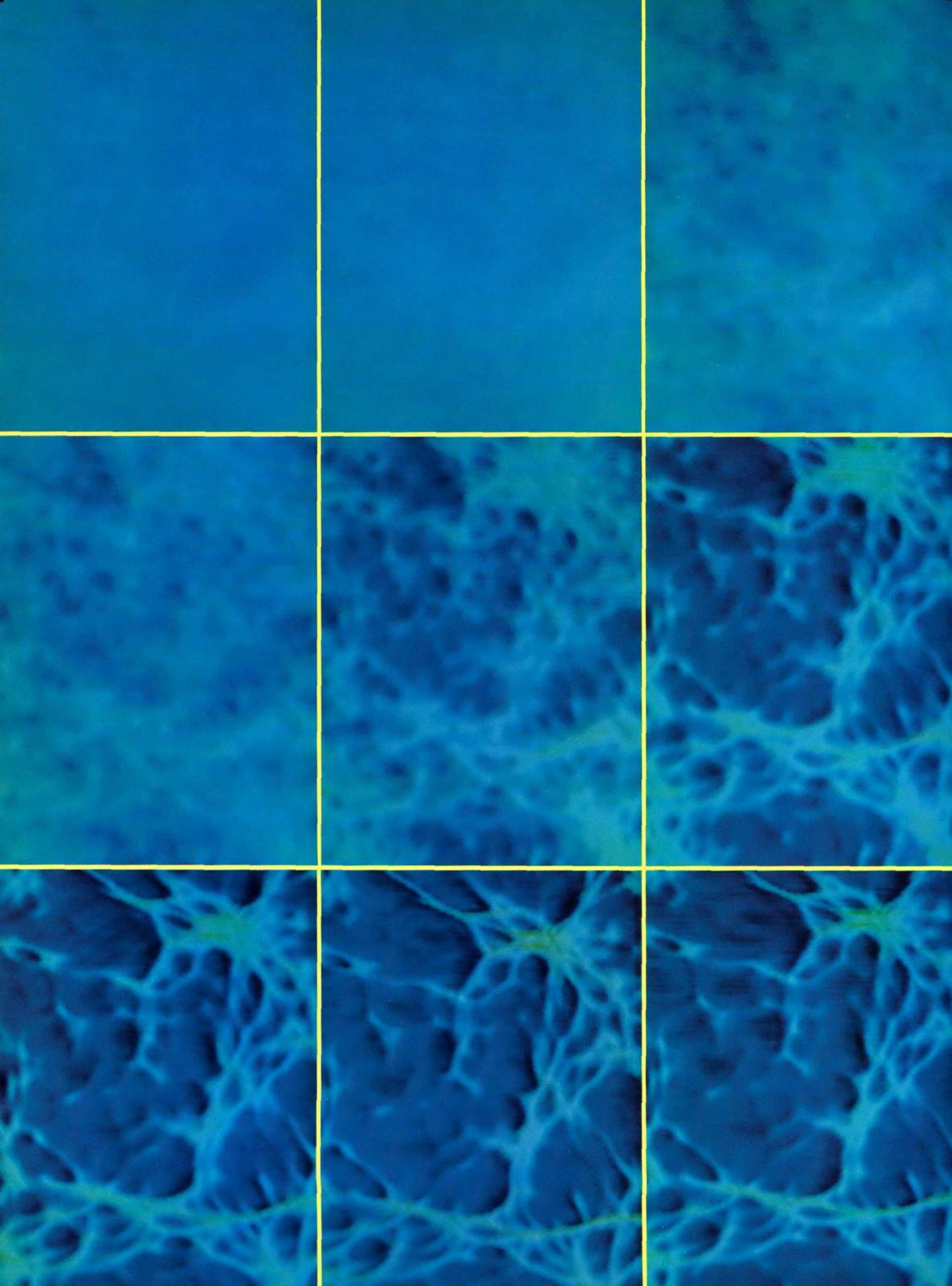
The disks and graceful arms of spiral galaxies may have formed in a later epoch, says Peebles. He notes as one of the observational clues that spirals have lots of gas that hasn't yet condensed into stars, so many of these galaxies continue to give birth to new stars. Peebles defines an even later epoch in which half the mass of a galaxy has been converted into long-lived stars.

The first epoch of formation may prove the most fundamental and the most challenging to explain. Two types of observations put the squeeze on any theory that attempts to account for these early lumps, according to Edwin Turner, also of Princeton University. "Theories are caught between the jaws of a vise," he says.

Turner notes that the cosmic microwave background, the radiation left over from the explosive birth of the universe, is remarkably uniform. This seems to imply that large-scale structure can't easily form very early in the cosmos. Yet mounting evidence indicates that some type of structure did form within the first billion years after the Big Bang. Turner's conclusion: Whatever prompted the universe to grow lumpy must have done so in a hurry.

LARGE-SCALE CLUMPING created not only galaxies but clusters of galaxies such as the Coma Cluster shown in this Wide Field and Planetary Camera image taken with the repaired Hubble Space Telescope.

William Baum, U. Wash./NASA/HST-WFPC1 team



To better understand this cosmic riddle, consider the microwave background. Soon after its 1989 launch, NASA's Cosmic Background Explorer satellite found that everywhere it looked on the sky, the background radiation had virtually the same intensity and temperature. COBE's measurements corroborate the view that the cosmos was once a hot, dense, and almost perfectly smooth mixture of radiation and matter. Two years ago, a team of astronomers led by George Smoot of the Lawrence Berkeley Laboratory in Berkeley, California, made headlines around the world when they announced that COBE had detected tiny hot and cold spots in this otherwise uniform background. (See "COBE's Big Bang," August 1992.)

The tiny fluctuations, measured in tens of millionths of a degree, reveal regions of slight overdensity and underdensity in the sky from a time when the universe was less than 300,000 years old. Under the influence of gravity, overdense regions grew bigger, acting as seeds for the galactic structure seen today. But the amplitudes of these primordial lumps were so tiny that they can't account for all the structure in the cosmos.

Cosmologists have tried to solve this predicament by assuming that the seeds of large-scale structure actually were bigger. They propose that the extra density comes from some kind of dark matter, material that remains invisible because it interacts only weakly, if at all, with light. (For the evidence regarding dark matter, see "Shedding Light on Dark Matter," February 1992.) Researchers have proposed two varieties of this unseen matter: cold dark matter, which moves slowly and tends to form galaxies soon after the Big Bang, and hot dark matter, which moves faster and forms galaxies long after the primeval fireball. In either case, dark matter acts as a catalyst, accelerating the growth of lumps and allowing large-scale structure to form earlier than it would with just the visible matter.

But could dark matter form structure fast enough?

Several lines of evidence suggest that the universe was noticeably lumpy soon after the Big Bang. Recently, Kate Isaak and Richard McMahon of the University of Cambridge and their colleagues went hunting for dust around 20 distant quasars. Using millimeter-wave telescopes, they found a dust cloud more massive than a hundred million suns around one of these luminous bodies, dubbed BR 1202-0725. At a distance of 13.8 billion light-years, this quasar has a redshift of 4.69, indicating that astronomers observe it as it appeared when the universe was about a billion years old. The huge cloud suggests that many massive stars had already formed and exploded as supernovas, spewing particles of carbon and silicon into the space around the quasar.

Or, the dust could come from material that gets blown out as a wind from the outer envelopes of massive, young stars. In either scenario, Isaak says, the presence of the dust indicates that large numbers of stars had already formed in the host galaxy that is assumed to surround the quasar. She reported the study last April in Edinburgh, Scotland, at a joint meeting of the Royal Astronomical Society and the European Astronomical Society.

HOT AND COLD DARK MATTER COMBINE in this supercomputer model to produce a universe that generates large structures such as clusters of galaxies as well as small features such as individual galaxies, within the first billion years of the universe's lifetime.

Greg Bryan and Michael Norman, U. Ill./NCSA

Another team of English researchers, headed by Steve Rawlings and Mark Lacy of the University of Oxford, recently discovered the most distant galaxy so far observed. This radio galaxy, called 8C 1435+635, has a redshift of 4.25 and lies some 13.7 billion light-years from Earth. (The previous record holder, a radio galaxy named 4C 41.17, has a smaller redshift of 3.8.)

The faintness of the galaxy in the infrared, its brightness at radio wavelengths, and the detection in visible light of what appears to be the redshifted glow of hydrogen gas all indicate that the team sees the galaxy as it appeared when the universe was just 8 percent of its current age, Rawlings says.

Whatever prompted the universe to grow lumpy must have done so in a hurry.

These and other observations are making some cosmologists "a bit uncomfortable," says Ellis. "We invented dark matter to accelerate galaxy formation," he notes. "Now we're saying that it may have gone on even faster than we thought."

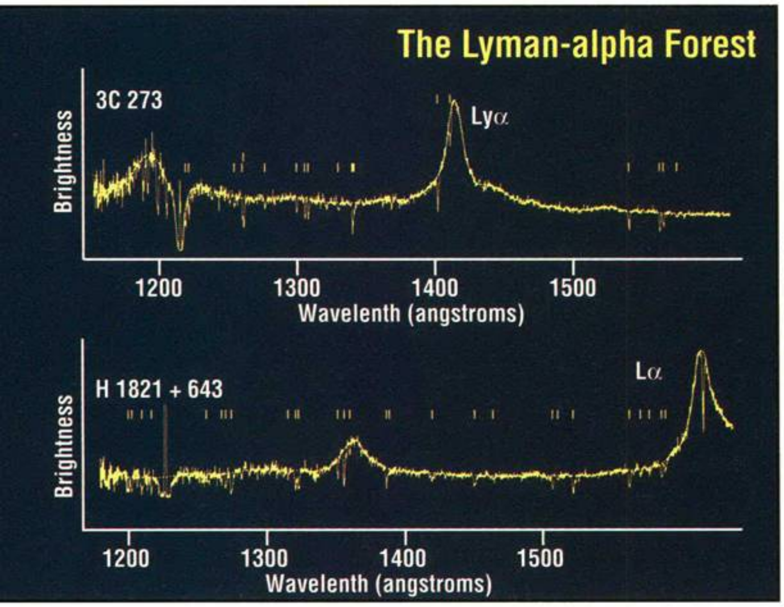
Compounding this problem is our ignorance about the total amount of matter in the cosmos, Ellis says. Whether or not structure can form rapidly depends in part upon whether we live in an open or closed universe, something that remains a matter of debate. An open universe has too little matter and will expand forever, while a closed cosmos contains enough matter that it will eventually collapse it on itself.

In an open universe, says Ellis, things are rushing away from each other so rapidly that they hardly have time to get acquainted, let alone clump into galaxies, galaxy clusters, or superclusters. "In an open universe, it's hard to form large-scale structure at all, even if you have all the time in the world," Ellis says.

Cold dark matter, he adds, may provide the correct general framework for galaxy formation, but "it's a theory out of kilter." For example, it predicts that most galaxies form between redshifts of two to four, but observations indicate that some structure formed earlier, at redshifts of at least five to 10. In addition, the model can't account for the large amount of clustering of galaxies seen today; the amount produced by cold-dark-matter models resembles the weak clustering in the universe about 10 billion years ago.

Tinkering with the cold-dark-matter theory, for instance by mixing in some hot dark matter, may remove some of the problems. And some researchers choose to ignore the early formation of such bizarre, rare objects as quasars and radio galaxies. These powerhouses may have little do with the formation and evolution of the typical galaxies that exist today, they say.

If some dismiss distant quasars as the oddballs of the universe, everyone takes seriously the clouds of hydrogen gas that lie between these faraway light beacons and observers on Earth. Like a group of foreground trees silhouetted by a distant searchlight, these clouds make their presence known by absorbing light from a background quasar.



John Bahcall, Inst. Adv. Studies, et al./NASA/HST FOS

THE SPECTRA OF GALAXIES REVEAL numerous dark lines mark by ticks. These lines are produced by clouds of gas that lie between our Milky Way Galaxy and the distant quasars. The ultraviolet line of hydrogen called Lyman-alpha (Lyα) is shifted toward the red from its usual wavelength of 1215 angstroms owing to the distances of the quasars: 3 billion light-years for 3C 273 and 4.8 billion light-years for H 1821+643.

Because quasars are hot, energetic objects, much of the light that they emit — and that the gas clouds absorb — lies in the ultraviolet, produced by the glow of hydrogen gas. The single strongest spectral line in the ultraviolet is produced when an electron in a hydrogen atom jumps from the first excited state to the ground state. This radiation is called Lyman-alpha in honor of the American physicist Theodore Lyman, who studied the ultraviolet spectrum of hydrogen in the laboratory during the first decade of this century.

Ultraviolet light can't penetrate Earth's protective ozone layer. Thus, Lyman-alpha emission or absorption from nearby objects isn't visible from the ground. But the expansion of the universe shifts the bright lines emitted by faraway quasars in the ultraviolet and the dark absorption lines from intervening gas clouds toward longer wavelengths, out of the ultrviolet and into the visible part of the spectrum. Because the clouds lie closer to Earth, their light shifts by a smaller amount and appears bluer than the spectra produced by the quasar. Thus a typical quasar spectra consists of a bright peak of Lyman-alpha emission with a series of faint, dark valleys on the blue side of this peak, created by numerous gas clouds spread over a range of distances.

Astronomers discovered the absorption lines, called the Lyman-alpha forest, more than 20 years ago. Most of the clouds are made of diffuse, low density gas. But in the mid-1980s, Arthur Wolfe of the University of California, San Diego, discovered that a few of the hydrogen-absorbing clouds weren't like the others. These clouds, dubbed damped Lyman-alpha absorption systems, have much more neutral hydrogen, notes Wolfe.

In fact, the total amount of hydrogen in the most distant of these systems may be enough to account for all the material found in galaxies today — both spirals and ellipticals. These clouds lie at redshifts of 2.5 to 3.5, roughly corresponding to distances between 12.5 and 13.5 billion light-years from Earth. Could these systems indeed be the ancestors of today's collection of star-studded galaxies?

Kenneth Lanzetta of the State University of New York at Stony Brook, together with Wolfe and David Turnshek at the University of Pittsburgh, recently decided to put this notion to a test. The researchers already had a large bank of data on the amount of hydrogen in distant, damped high-redshift Lyman-alpha absorbers. Now they wanted to examine those absorbers that lie closer than a redshift of 1.6, roughly 11.5 billion light-years from Earth.

Telescopes are like time machines: The more distant an object that astronomers peer at, the further back in time they are looking. Thus, studies of nearby damped Lyman-alpha absorbers tell us about more recent times in the universe than absorbers that lie farther away.

But because the nearby absorbers have a lower redshift, the ultraviolet light they absorb from quasars gets shifted only slightly. The radiation remains in the ultraviolet and can't penetrate Earth's atmosphere. So Lanzetta and his colleagues sifted through data taken by a telescope in space, the International Ultraviolet Explorer, now in its seventeenth year of operation. Spectra taken with the IUE show that nearby absorbers have significantly lower amounts of hydrogen gas than those of their high-redshift counterparts. After subtracting for the expansion of the universe, which naturally creates a lower-density cosmos now than in the past, the low-redshift absorbers have about one-seventh the amount of hydrogen gas than the more distant systems.

Where did all the gas go? The team speculates that as the universe aged, the hydrogen gas in the absorber

GALAXIES MAY HAVE FORMED EARLY but some took on their final shapes in the last 6 or 7 billion years. For example, spiral galaxies, such as M83 in Hydra shown here, may have developed their spiral arms and disks late in the universe's history.

NOAO

PRIMITIVE GALAXIES MAY ELUDE detection because their hot, bright stars enshroud themselves with dust. New submillimeter telescopes may finally view the energy reradiated by the dust and, thus, uncover these objects.

systems condensed and formed stars. The researchers consider the new finding additional evidence that the damped Lyman-alpha absorbers helped spawn the galaxies we see around us.

Lanzetta notes one caveat to the new study, which will be published in an upcoming issue of the *Astrophysical Journal*. Some astronomers previously associated the absorber systems only with the formation of spiral galaxies, such as the Milky Way, not ellipticals. But the high-redshift absorbers have a very low abundance of metals (elements heavier than helium). That's a characteristic of stars in elliptical galaxies, but not spirals. So the identification between the damped Lyman-alpha absorbers and galaxy evolution only seems to work if the absorbers are the progenitors of both types of galaxies, Lanzetta says. In this model, the absorbers would farm out most of their metal-poor gas to ellipticals.

"Quasars are rare objects, sort of flukes in the universe. But the absorber clouds seem to be the forerunners of much of the material in galaxies," concludes Wolfe.

Now that Wolfe and his colleagues have analyzed the amount of hydrogren in gas in very low-redshift absorber systems, they plan to study systems at the other extreme — those that have a redshift greater than 3.5. Analyzing the absorption spectra with the 10-meter W. M. Keck telescope in Hawaii, the team will try to determine if the amount of hydrogen in these very distant clouds continues to increase with redshift or whether it levels off.

If the amount remains level, it may indicate that the researchers have found the epoch when many galaxies first formed. If the amount increases so much that the distant absorbers contain more material than is visible in galaxies today, it could indicate that they hold some of the dark matter destined for galaxies.

Still, astronomers have yet to find the Rosetta stone for the origin of galaxies. "We aren't convinced that we've yet seen a galaxy caught in the act of forming," says Ellis. "When we look back in time 5, 6, or 7 billion years ago, we still see galaxies with beautiful spiral arms."

Several new observations may boost the chances of finding primeval galaxies, Ellis notes. Many astronomers believe that primitive galaxies have eluded detection because they lie cloaked in dust produced by the first generation of massive stars. Such stars last for only a few million years, and in their explosive death as supernovae could pepper the fledging galaxy with dust particles. Heated dust glows in the infrared, but such light, emitted from a very distant, primeval galaxy, would be redshifted to longer, millimeter wavelengths.

No one has had the equipment to image a distant galaxy at millimeter wavelengths. But next year a millimeter-wave telescope in Hawaii, the James Clerk Maxwell telescope, will be outfitted with a new detector array capable of taking such images. Researchers including McMahon will use the array to hunt primeval galaxies.

Finding one or two of these distant, dusty objects would thrill astronomers, Ellis says. But even more compelling, he adds, would be to predict, based on the amount of mass in galaxies today, how many primeval galaxies there should be in a given area of the sky and then find that number.

The phenomenon of gravitational lensing may also provide new information about galaxy formation. Using a massive cluster of galaxies as a lens to gravitationally magnify and brighten distant objects that lie behind it, astronomers may view faraway galaxies that would otherwise be too faint to view. About 20 such lensing systems are now known, Ellis notes.

In addition, a wide variety of ground-based and balloon-borne detectors are now examining the cosmic microwave background on a scale that complements the COBE survey. These experiments are looking for hot and cold spots in the microwave background over much smaller patches of sky than COBE could study. The fluctuations COBE saw correspond to the formation of structures much bigger than the largest superclusters of galaxies; the new experiments seek the smaller fluctuations that evolve into clusters of galaxies or even individual galaxies.

We haven't yet caught a galaxy in the act of forming.

"It's no good trying to speculate exactly how to solve the problem of galaxy origin and evolution," says Ellis. "Very soon we're going to be able to say whether there are dusty galaxies at a redshift of five. The cosmic microwave background will be nailed down more completely. And with the Hubble Space Telescope, we'll see the shapes of many galaxies around the vicinity of quasars." For understanding the origin of galaxies, he concludes, "we're about to enter a very exciting time." ☐

Ron Cowen lives in the Washington, D. C. area and writes for Science News. *This is his first article for* Astronomy.

Bob Eggleton

SKY ALMANAC

December 1994

Geminids Peak on December 13/14

The nearly Full Moon hampers viewing of the Geminid meteor shower at its peak on the morning of December 14. Still, you should be able to spy 50 to 60 of the normally white or yellow meteors in the brief window between when the Moon sets and morning twilight commences.

Venus, Jupiter, and the Moon

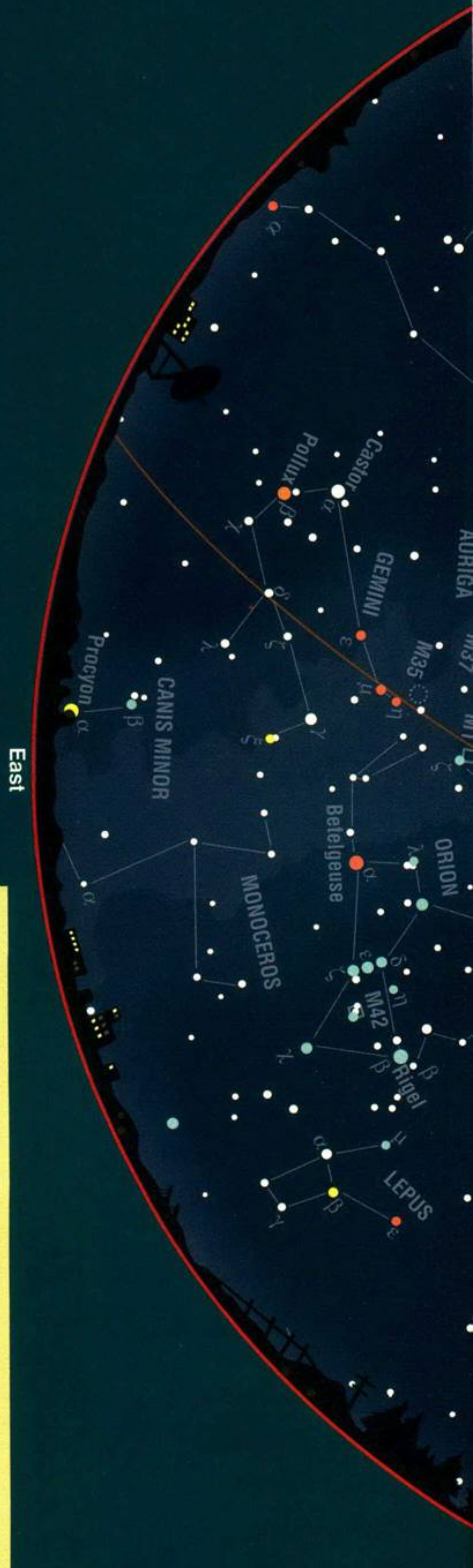
On the morning of December 29, don a heavy jacket, head outside, and look toward the southeastern horizon. About an hour before sunrise that day, your gaze will fall upon the three brightest objects visible in the night sky. Sandwiched by the two brightest planets — Venus and Jupiter — is the silvery sliver of the waning crescent Moon.

Mars Returns to Prominence

After a nearly two-year hiatus during which the Red Planet remained small, low in the sky, and fairly inconspicuous, Mars returns to glory this month. Casual observers will see the planet glowing brightly at magnitude 0.0 in mid-December, and it gains brightness rapidly after that. Meanwhile, telescopic observers will note the planet appears larger than 10" across, making the normally subtle surface features stand out more easily on the ocher disk.

Vesta Reaches Opposition on December 24/25

The brightest asteroid in the solar system, 4 Vesta, appears opposite the Sun in our sky this month and is perfectly placed in northern Orion for backyard observers. If you have good eyesight and observe from a dark-sky site, you may even be able to glimpse this asteroid with your naked eye.



CALENDAR OF EVENTS

2 The Moon is at perigee (221,994 miles from Earth), 7:20 a.m. EST
New Moon is at 6:54 p.m. EST

4 Asteroid Flora is at opposition

5 The Moon passes 4° north of Neptune, 2 p.m. EST
The Moon passes 6° north of Uranus, 7 p.m. EST

8 Mars passes 2° north of Regulus, 3 a.m. EST
The Moon passes 7° north of Saturn, midnight EST

9 Venus is at greatest brilliancy (magnitude –4.7), 6 a.m. EST
First Quarter Moon is at 4:06 p.m. EST

13 Mercury is in superior conjunction, 10 p.m. EST
Geminid meteor shower peaks

15 The Moon is at apogee (252,288 miles from Earth), 2:48 a.m. EST
Asteroid Astraea is at opposition

17 Full Moon is at 9:17 p.m. EST

21 Winter solstice is at 9:23 p.m. EST

23 The Moon passes 9° south of Mars, 10 a.m. EST

24 Asteroid Vesta is at opposition

25 Last Quarter Moon is at 2:06 p.m. EST

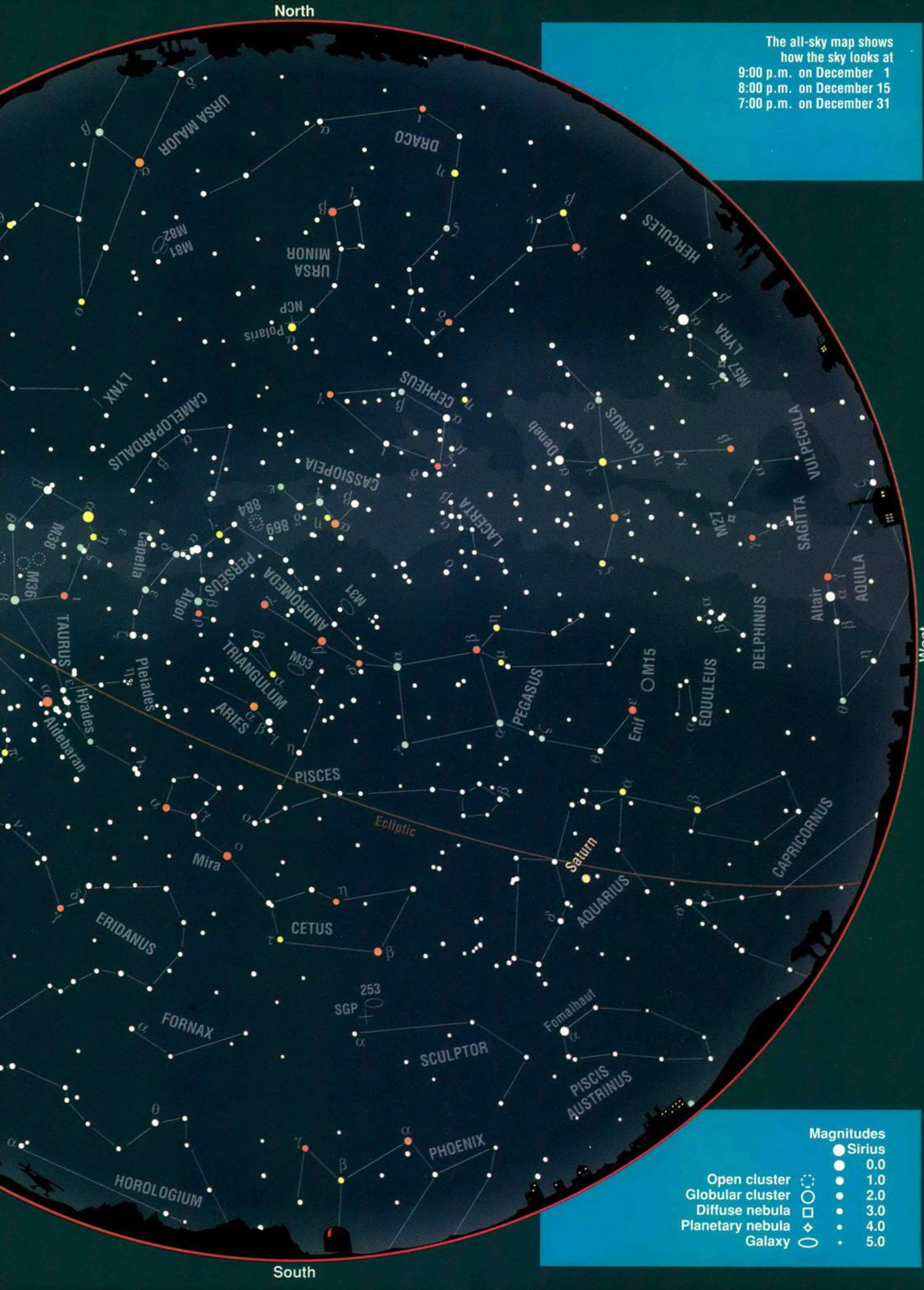
27 The Moon passes 0.3° north of Spica, 1 a.m. EST

28 Asteroid Eunomia is at opposition
The Moon passes 3° south of Venus, midnight EST

29 The Moon passes 1.1° north of Jupiter, 7 p.m. EST

30 The Moon is at perigee (223,997 miles from Earth), 6:05 p.m. EST

The all-sky map shows
how the sky looks at
9:00 p.m. on December 1
8:00 p.m. on December 15
7:00 p.m. on December 31


North
URSA MAJOR
DRACO
M81
M82
URSA MINOR
NCP
Polaris
HERCULES
Vega
LYRA
M57
LYNX
CAMELOPARDALIS
CEPHEUS
CYGNUS
Deneb
VULPECULA
CASSIOPEIA
LACERTA
M27
SAGITTA
Capella
M38
M36
869
884
PERSEUS
Algol
ANDROMEDA
M31
AQUILA
Altair
DELPHINUS
TAURUS
Pleiades
Hyades
Aldebaran
TRIANGULUM
M33
ARIES
PEGASUS
M15
Enif
EQUULEUS
West
PISCES
Ecliptic
Mira
Saturn
CAPRICORNUS
AQUARIUS
ERIDANUS
CETUS
253
SGP
FORNAX
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
PHOENIX
HOROLOGIUM
South

Magnitudes

● Sirius
● 0.0
● 1.0
● 2.0
● 3.0
● 4.0
● 5.0

Open cluster ◌
Globular cluster ○
Diffuse nebula □
Planetary nebula ✧
Galaxy ⬭

SKY ALMANAC

by Deborah Byrd and Rick Shaffer

In mid-December Earth passes through a swarm of tiny dust particles left behind by a comet orbiting the Sun. As Earth fords this meteor stream, many of those particles slam into our atmosphere, vaporizing as they fall. Their fiery demise creates a light show in our night sky called the Geminid meteor shower. Watchful observers should see approximately 60 meteors per hour, or one a minute, under dark country skies before dawn on December 14.

Witnessing the shower under a dark sky will be more difficult than in most years, however. The waxing gibbous Moon sets only about three hours before the Sun rises on the morning of the 14th, washing the sky with its silvery light for most of the night. You have only a narrow window for seeing a good display, after the Moon sets and before dawn begins to light the sky. Be sure to gather some warm clothes before trekking to a dark rural site.

Geminid meteors appear to radiate from near the star Castor in the constellation Gemini, hence their name. From midnorthern latitudes, the radiant rises in the early evening and passes nearly overhead around 2 a.m. But don't stare at the radiant. Even though the meteors appear to emanate from this point, the length of a meteor's trail grows the farther it is from the radiant. Your best bet is to simply lie back and scan a wide area of sky with your naked eye.

As Geminid meteors streak overhead, you will no doubt notice a bright orange-reddish light high in the southeast. This is the Red Planet, Mars, which rises around 10 p.m. in mid-December and lies near the bright star Regulus in the constellation Leo. At magnitude 0.0, Mars now shines more than a magnitude brighter than Regulus, and the planet's ruddy color contrasts nicely with the white star. On December 8, the planet passes 2° north of Regulus in the first of three conjunctions between the two in 1994-95.

Mars grows to 10" in apparent diameter this month, surpassing what many telescope observers consider the minimum size for seeing detail on the planet's surface. Would we define this limit in this way if we didn't have 10 fingers and 10 toes? No matter. The important thing is that it now looms large enough that observers armed with medium-sized telescopes can see many subtle surface features.

The brightest planet, Venus, reaches greatest brilliancy on December 9, when it can be found in the southeast before dawn shining with astounding brilliance at magnitude –4.7. Another very bright object, the second-brightest planet, lies below Venus that morning. It is Jupiter, which rises earlier and thus climbs higher in the southeastern predawn sky with each passing morning. By late December, Jupiter rises only an hour after Venus. The waning crescent Moon appears between the dazzling duo on the morning of December 29.

Comet Borrelly rides high in the northern sky on these December nights. Glowing at 8th magnitude among the stars of Ursa Major, the comet is an easy binocular target. It

All Eyes on the Geminids

Even though balmy weather draws many more people to watch the Perseids in August, the Geminid meteor shower in mid-December has been providing as good a show for at least the last two decades. That's the good news for meteor observers this month. The bad news is that this year the shower occurs just four days before Full Moon, so bright moonlight will do its best to drown out the meteors.

To see the most Geminids, probably about 60 per hour, observe from a dark-sky site on the morning of December 14 after the Moon sets but before twilight begins. That gives you nearly two hours of complete darkness, in which to drink in the shower. Geminid meteors tend to be bright, with two-thirds appearing white, one-quarter yellow, and the rest blue, green, orange, or red. And they smash into Earth's atmosphere at moderate speeds (for meteors) of about 22 miles per second.

For most observers, viewing the Geminids means dealing with cold weather. Here are a few tips: Orient the vehicle that brought you to the dark-sky site (or any structure that may be available there) so you can observe in the lee of the wind. If you own a pickup truck, face the cab into the wind to provide a windbreak and recline on a low lawn chair in the bed of the truck as you watch the sky.

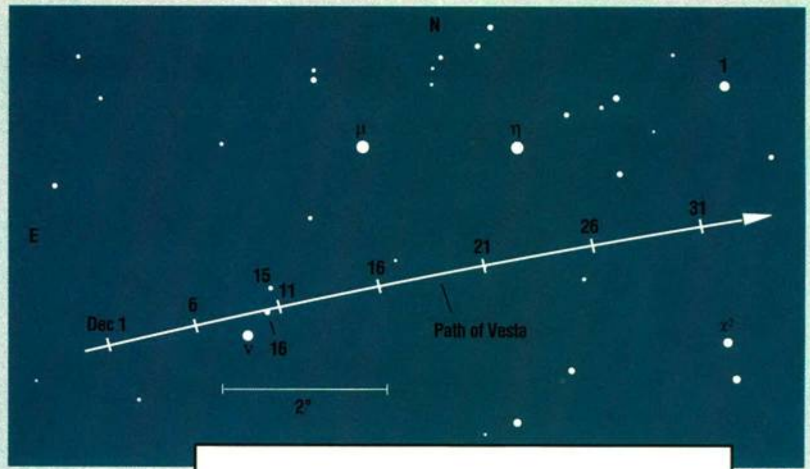
Wear several layers of clothes against the cold, but don't get so snuggled-up that you doze off for a long winter's nap. If you tend to fall asleep during observing sessions, consider an after-dinner nap. Also keep a pair of binoculars handy for observing the occasional luminous trail left by a meteor. Finally, a thermos of coffee, tea, or hot soup will help ward off the chill and a few candy bars or cookies will keep your energy level up.

Mirco Villa

A Holiday Asteroid

As a year-end holiday gift, the brightest asteroid appears opposite the Sun in our sky on the night of December 24/25. Vesta then lies in the club of Orion, just south of Gemini's feet, placing it high in the sky around midnight. If you just received a telescope or binoculars as a gift, finding and following Vesta for a few weeks offers a good way to acquire skills you'll use again and again.

The most fun, though, could be spotting Vesta with your naked eye. From a clear, dark observing site, many observers can see stars approaching 7th magnitude. This means spotting a 6.3-magnitude asteroid shouldn't be the challenge of your observing career. To do so, use the finder chart or table of coordinates to home in on Vesta (positions are shown for 11 p.m. EST, 10 p.m. CST, 9 p.m. MST, and 8 p.m. PST). Bring a red flashlight along so you can see the map in the dark, and allow at least half an hour to get dark adapted. While seated in a recliner or chaise longue, gaze at Vesta's location in Orion's club. If you don't see Vesta on your first night out, don't despair. With perseverance and a dark, steady night, you can find this asteroid with just your eyes.

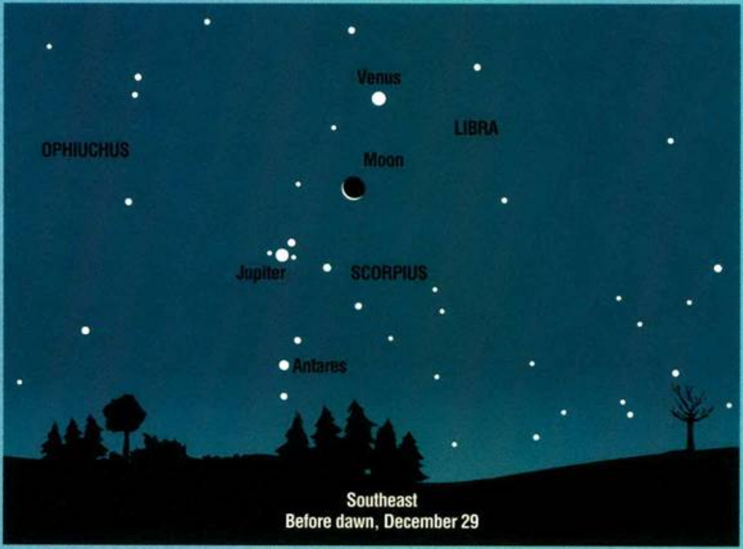


COORDINATES FOR VESTA

Date	R.A. (2000)	Dec.
December 1	6h36.2m	20°06'
December 6	6h32.0m	20°19'
December 11	6h27.3m	20°33'
December 16	6h22.1m	20°48'
December 21	6h16.6m	21°03'
December 26	6h10.9m	21°19'
December 31	6h05.3m	21°34'

A Stunning Gathering in the Morning

Jupiter joins Venus in the predawn sky late this month. Venus rises more than three hours before the Sun and Jupiter follows about an hour later. By an hour before sunrise, both stand prominently above the southeastern horizon. If you receive a new telescope as a holiday gift, Venus and Jupiter will make tempting targets to get your observing started. Venus appears as a thick crescent in the eyepiece, while Jupiter displays two prominent dark belts and four bright moons. The big unknown with Jupiter is whether any evidence will remain of the dark clouds created when Comet Shoemaker-Levy 9 crashed into Jupiter last July.



Before dawn, December 29

Probably the most visually exciting event of the month comes on the morning of December 29, when a very old Moon joins Venus and Jupiter low in the predawn sky. It seems appropriate to experience this scene in solitude during the peaceful last hour before a winter's sunrise. After all, that's part of what amateur astronomy is all about. But sharing your love of the sky is part of it too. So try persuading your family to get up a bit early to see this rare grouping with you.

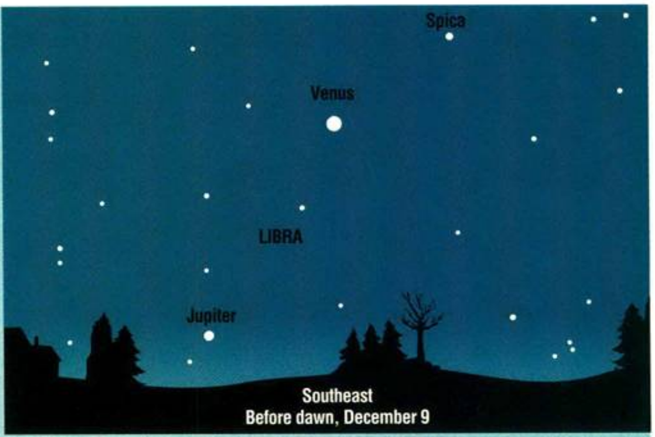
The gathering of the three brightest objects in the night sky also presents a magnificent photo opportunity. All you need to capture the scene is a tripod-mounted SLR camera. Set its lens near the smallest f/number possible and focus on infinity. To really set the photo apart, try to frame the shot with a church steeple or some other impressive foreground. If there's a newly fallen carpet of snow, so much the better. Use fast film (400 ASA or faster) and a broad range of exposures, say 1, 2, 4, 8, 16, and 32 seconds. One of those should capture the scene perfectly — and give you a unique photo to use on next year's holiday card.

passes closest to Earth, at a distance of about 60 million miles, on December 4.

The brightest asteroid, 4 Vesta, reaches opposition on Christmas Eve. That's when Earth passes more or less between this minor planet and the Sun. On that date Vesta lies in far northern Orion and shines at magnitude 6.3, near the limit of naked-eye visibility. You should be able to spot it with the naked eye from a pitch-black observing site, but the task will be easier if you first find it with binoculars. Vesta can be a magnitude brighter if opposition coincides with perihelion (its closest point to the Sun), but Vesta was farthest from the Sun in early October.

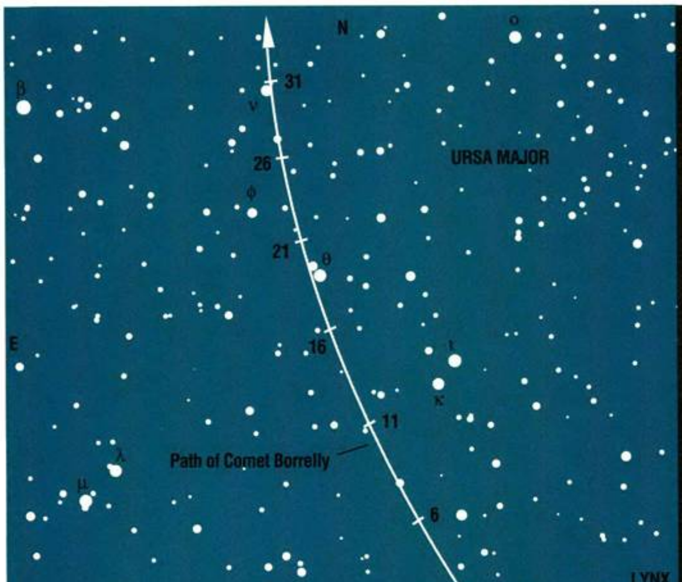
December rates as an exceptional month for bright asteroids. On December 4/5, 8 Flora comes to opposition

Venus Shines Brilliantly



Venus will knock your dark-adapted socks off all month, but never more so than on the morning of December 9. That's when the planet attains greatest brilliancy for this morning apparition, shining at an impressive magnitude of –4.7.

But extreme brightness is only part of what Venus offers this month. For telescopic observers, the planet provides a constantly changing appearance as its phase waxes and diameter shrinks. On the 1st, Venus appears a whopping 46" across but just 19 percent illuminated. At greatest brilliancy on the 9th, the planet is 40" in apparent diameter and shows a 27-percent-lit crescent. And by the end of the month, Venus measures 29" across with a 42-percent-lit disk.



Comet Borrelly High in the North

One of the best comets of 1994, Comet Borrelly, comes closest to Earth in early December. At a distance of 57 million miles, this dirty snowball then glows at 8th magnitude, a level it maintains for most of December as it climbs north from Lynx into Ursa Major. (Positions in the finder chart and table are given for 11 p.m. EST, 10 p.m. CST, 9 p.m. MST, and 8 p.m. PST.)

Because Sky Almanac in October and November talked about how and where to observe Borrelly, this month we'll concentrate on photographing the comet. And since it passes south and west of the Big Dipper, a wide-angle lens will let you capture Borrelly as it nears the sky's most easily recognized asterism.

To take the photos, choose an SLR camera loaded with moderately fast film (around 400 ASA should work well). Then stop down the aperture by two full f/numbers, so if the wide open speed is f/1.4, take your exposures at f/2.8 or even f/4.5. This means longer exposure times, but the improvement in image quality will be worth it.

Firmly attach your camera to some sort of equatorial mount or platform that allows you to automatically track the sky. For the sharpest possible photos, piggyback the camera on a well-aligned scope and guide with a medium-powered eyepiece.

If you attempt a series of photographs capturing Borrelly as it passes through Ursa Major, try to orient the Big Dipper the same way relative to the edge of each frame. By viewing all the slides in rapid succession, you then can see a kind of motion picture of the event.

COORDINATES FOR COMET BORRELLY

Date	R.A. (2000)	Dec.
December 1	8h58.9m	37°35'
December 6	9h10.2m	41°40'
December 11	9h20.7m	45°40'
December 16	9h30.2m	49°30'
December 21	9h38.3m	53°05'
December 26	9h44.9m	56°23'
December 31	9h49.7m	59°19'

among the background stars of northwestern Orion, but by midmonth it moves into Taurus. At magnitude 8.0, it glows brighter than any other asteroid this year, with the exceptions of Vesta and Ceres.

Telescopic observers will want to watch as Saturn continues eclipsing its own satellites. Viewers should also note the planet's rings, which appear increasingly edge-on as seen from our vantage point. Earth will pass through the ring-plane in May, when the glorious rings of Saturn will seem to disappear.

December's Planets

Uranus and **Neptune** lie low in the southwest after sunset as December begins, barely shining through the gathering dusk. By the end of December they have disappeared in the Sun's glare, preparing to pass behind the Sun in January.

Saturn shines gently in the south as darkness falls, setting before midnight. Although the planet appears somewhat fainter, at magnitude 1.0, than it did this past summer or fall, it remains much brighter than the stars of its host constellation, Aquarius. Telescopic observers should view Saturn early in the evening while it is still fairly high in the sky and its light doesn't have to traverse as much of Earth's image-blurring atmosphere.

Just about the time Saturn sets, **Mars** rises above the eastern horizon. The Red Planet brightens rapidly this month as Earth comes closer to passing between it and the Sun next February. It shines at magnitude 0.3 on December 1 and magnitude –0.3 on the 31st, a gain in brightness of some 75 percent. On December 8, the planet passes 2° north of 1st-magnitude Regulus, the brightest star in the constellation Leo.

A telescope reveals Mars as a much more intriguing place than it was earlier this year. The planet's disk now appears 10" in diameter, and some normally subtle details should be coming into view. In particular the Martian north polar cap appears prominent because the planet's northern hemisphere is now only two months into

Saturn's Moons in Eclipse

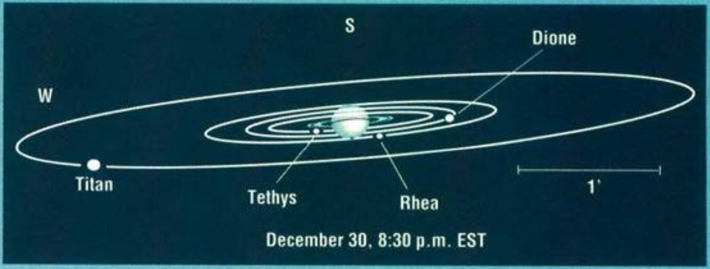
Approximately every 15 years (roughly half of Saturn's 29.5-year orbital period), both Earth and the Sun pass through the plane of Saturn's rings. The rings then appear edge-on or unlit, respectively, and disappear from view for a little while. The next ring-plane crossings occur in 1995.

Because the orbits of Saturn's satellites lie nearly in the plane of the rings, this is also a time when the satellites pass directly in front of and behind the planet and through the planet's shadow. For more than a year before and after ring-plane crossing, Saturn eclipses some of its satellites. As you might surmise, eclipses happen most often around ring-plane crossings and trail off from there. December features 11 events involving Dione and Rhea, with six visible from all or part of North America. With Saturn now sinking rapidly in the southwestern sky after sunset, this will be the last good opportunity until May to see one of these eclipses.

During an eclipse, Saturn blocks all the light that would normally reach the satellite. Thus the only part of an eclipse worth viewing is when the satellite either enters Saturn's shadow or re-emerges into sunlight. December features only re-emergences because the eclipses begin while the satellites lie behind the planet from our view. The re-emergences last anywhere from 150 to 400 seconds.

The table shows when these events occur. Each of this month's events occurs between 5" and 7" northeast of Saturn's limb, close to the planet's glare, so be sure the optics in your telescope are scrupulously clean to minimize scattered light. Dione glows at around 11th magnitude when it comes out of eclipse, so it will be hard to see. Observing those re-emergences will require excellent seeing, at least an 8-inch telescope, and a practiced eye.

The seven Rhea events will be a little easier to see because Rhea is 0.7 magnitude brighter and a bit farther from Saturn than Dione. Under good observing conditions, you should be able to glimpse Rhea re-emerging with a 6-inch scope.



December 30, 8:30 p.m. EST

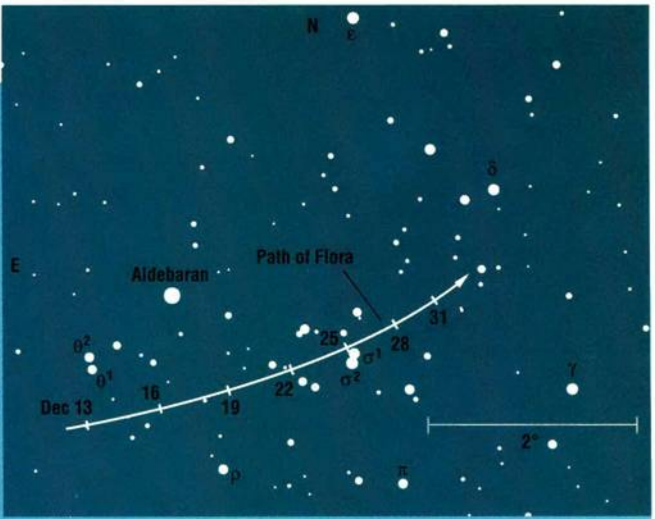
EVENTS OF THE SATURNIAN SATELLITES

Date	Begin Time	End Time	Event	Type of Event
December 3	6h20.3m	6h22.8m	Saturn eclipses Dione	Reappearance
December 3	22h26.3m	22h32.9m	Saturn eclipses Rhea	Reappearance
December 6	0h03.1m	0h05.6m	Saturn eclipses Dione	Reappearance
December 8	10h56.9m	11h03.2m	Saturn eclipses Rhea	Reappearance
December 8	17h45.9m	17h48.3m	Saturn eclipses Dione	Reappearance
December 11	11h28.6m	11h31.1m	Saturn eclipses Dione	Reappearance
December 12	23h27.3m	23h33.5m	Saturn eclipses Rhea	Reappearance
December 17	11h57.7m	12h03.6m	Saturn eclipses Rhea	Reappearance
December 22	0h27.9m	0h33.7m	Saturn eclipses Rhea	Reappearance
December 26	12h58.1m	13h03.6m	Saturn eclipses Rhea	Reappearance
December 31	1h28.1m	1h33.5m	Saturn eclipses Rhea	Reappearance

Begin Time: Universal time at beginning of event. (Subtract 5 hours to convert to EST, 6 hours for CST, 7 hours for MST, and 8 hours for PST.) **End Time:** Universal time at end of event. **Event:** The nature of the event and the objects involved. **Type of event:** Whether the satellite is reappearing or disappearing.

COORDINATES FOR FLORA

Date	R.A. (2000)	Dec.
December 13	4h39.4m	15°16'
December 16	4h36.4m	15°26'
December 19	4h33.6m	15°37'
December 22	4h31.1m	15°48'
December 25	4h28.8m	16°01'
December 28	4h26.9m	16°14'
December 31	4h25.3m	16°28'



Asteroid Flora Glides Through the Hyades

Although Vesta is easily the brightest asteroid in December (see page 57), 8 Flora certainly merits your attention. During the second half of the month, Flora passes through the Hyades cluster, the arrowhead-shaped asterism that forms the face of Taurus, the Bull.

Flora reaches opposition on December 4/5, when the asteroid glows at magnitude 8.0. But the favorable geometry of Earth's and Flora's orbits keeps the 95-mile-diameter minor planet brighter than 9th magnitude all month. You can find Flora by using the finder chart above or table of coordinates at left (positions are shown for 11 p.m. EST, 10 p.m. CST, 9 p.m. MST, and 8 p.m. PST).

THE STARRY SKY

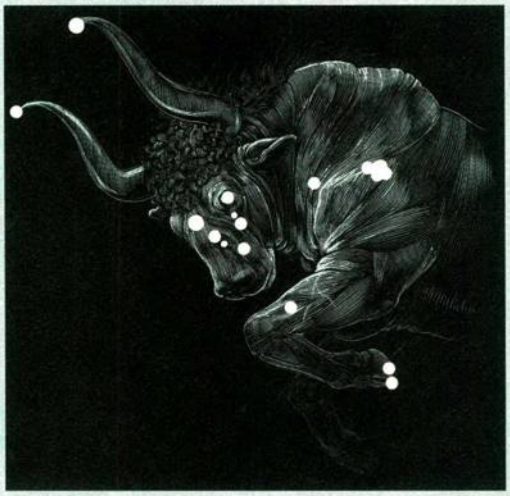
by Deborah Byrd

One of the most ancient constellations, Taurus, the Bull, appears prominent in the winter sky. This is one of the earliest named star groups because it once marked an important location in the sky. From about 4000 to 1700 B.C., the Sun resided in Taurus at the vernal equinox, the first day of spring. As Steven L. Beyer points out in his book *The Star Guide*, the bull was "a symbol of the vitality of spring."

In Greek mythology, the bull's legendary vitality expressed itself in other ways. The bull is identified with the king of the gods, Zeus, whose amorous adventures included swimming through the sea in the form of a bull with the beautiful maiden Europa on his back.

Taurus is easy to identify by an asterism, a recognizable pattern of stars, known as the Hyades. This V-shaped grouping of stars represents the bull's face. The brightest star in the asterism, and in all of Taurus, is orangish Aldebaran, which marks the bull's fiery eye.

The Hyades forms an open star cluster, a collection of stars held together loosely by gravity, one of six fairly bright open clusters in Taurus. An open cluster's stars are born from a single cloud of gas and dust in space, and for a time these stars are like children who stay within their own family circle. An open star cluster ultimately falls apart, however, with its member stars going their separate ways because of gravitational interactions between cluster members and the pull of the Galaxy at large. The fainter open clusters in Taurus include NGC 1647, NGC 1746, NGC 1807, and NGC 1817.


Keith Ward

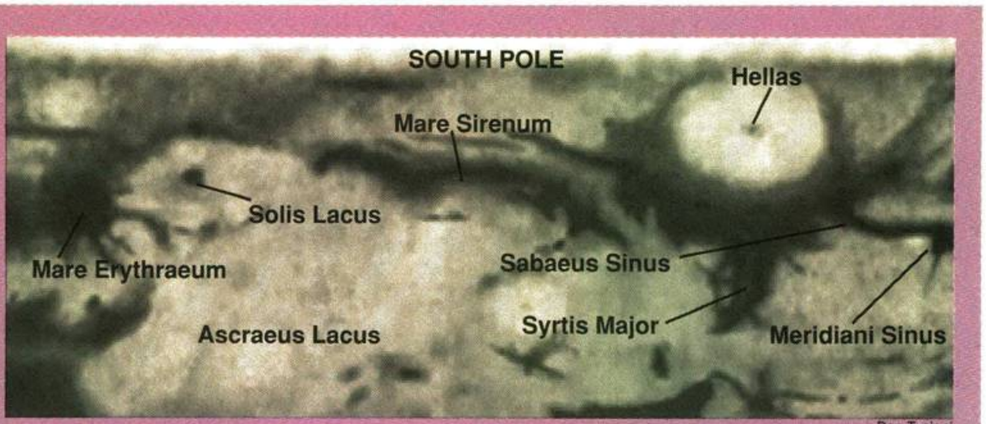
Some open star clusters can be seen with the naked eye. One is the famous Pleiades, or Seven Sisters, which represents the shoulder of the bull. The Pleiades looks like a tiny misty dipper of stars to the eye. Telescopes reveal hundreds of stars.

Binoculars or a rich-field telescope also reveal the V-shaped Hyades as a multitude of glittering stars. The bright star Aldebaran is a foreground object lying some 80 light-years closer than the 150-light-year-distant Hyades cluster. Like all open clusters, the Hyades is relatively young. Astronomers estimate it to be about 650 million years old, in contrast to the four-and-a-half-billion-year-old Sun.

Another object in Taurus represents an even earlier phase of a star's life. T Tauri — a variable star that ranges from 8th to 13th magnitude and lies about 5° northwest of Aldebaran — is the prototype for a class of stars thought to be so young that they are still collapsing gravitationally. These stars, which vary erratically in brightness, are probably less than a million years old.

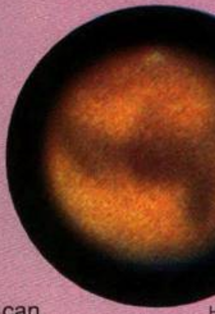
But as birth and death both are part of life, so they coexist within the boundaries of the constellation Taurus. A 6- to 8-inch telescope reveals a fairly bright oval patch in this constellation, known as the Crab Nebula (M1). This is the remnant of a supernova, a star that literally blew up at the end of its life, witnessed by Chinese astronomers in 1054. (See "Inside the Crab Nebula," page 42, for the latest images of this supernova remnant.)

Mars Grows Large in the Eyepiece



Dan Troiani

Now just two months away from its opposition, Mars grows rapidly in apparent size during December. Through a telescope, the Red Planet swells by more than a quarter, from 8.6" to 11.0" across, crossing the 10" threshold at which most backyard observers can begin to see subtle details on the surface of Mars. Those last four words — "the surface of Mars" — might seem relatively innocuous, but they speak volumes. Why? Because of all the planets, only Mars has a surface we can easily observe from Earth. Sure, it's technically true that we can observe the cratered surface of Mercury and the iceball that is Pluto, but Mars is the only planet that has a surface on which appreciable detail can be seen in a backyard telescope.



Harold Moore

Features visible on Mars are not individual craters, or the enormous canyon Valles Marineris, although these have been glimpsed by experienced observers using large telescopes under perfect conditions. No, what we see are albedo features, either regions where the material on the planet's surface reflects light well and thus appears bright pink, or mostly absorbs light and appears dark gray or dark green because of the contrast with the pink areas.

The light albedo features are mostly sandy areas, and the dark areas are those that the strong winds of Mars have scoured clean of sand, revealing the darker, rougher surface beneath. What makes observing Mars so fascinating is that the winds keep moving the sand around a bit, so the features are ever changing.

MARTIAN CENTRAL MERIDIANS

Date	Central Meridian
December 1	202°
December 4	174°
December 7	145°
December 10	117°
December 13	89°
December 16	61°
December 19	33°
December 22	6°
December 25	338°
December 28	310°
December 31	283°

Map has longitude 180° running down the center. Central meridians are for 4 a.m. EST. To find the meridian at other times, subtract 9.1° for each day after a tabulated date and add 14.6° for each hour after a tabulated time.

The winds don't control all the features, however. The polar caps — thin layers of water ice and frozen carbon dioxide — rank as the most striking features on the disk of Mars because they reflect the Sun's light almost perfectly. It's now spring in the northern hemisphere of Mars, and the north polar regions tilt toward us. That means that over the next few months, we can watch the north polar cap shrink steadily as the Martian seasons march on.

spring and that hemisphere tilts toward Earth.

Mars is the only planet visible from late evening when Saturn sets until about 4 a.m. The next planet to appear is the brightest of all, **Venus**, a brilliant beacon shining in the southeastern sky. This planet reaches greatest brilliancy on December 9, when it shines at magnitude –4.7. A peek through a telescope reveals a large disk — 40" in diameter — that's less than 30 percent illuminated.

Venus lies in Virgo when the month begins, a little below and to the left of Spica, Virgo's brightest star. During the course of the month, it passes into Libra and goes between Alpha and Beta Librae, also known as Zubenelgenubi and Zubeneschamali, after midmonth. It remains in Libra through the end of the year.

Meanwhile, as the days pass, look for another bright planet to emerge below Venus in the predawn twilight sky. This is **Jupiter**, the largest planet in our solar system and the second-brightest as seen from Earth. At magnitude –1.7, Jupiter shines much fainter than Venus but brighter than any star. The two brightest planets appearing near each other make an unbeatable combination, at least until the crescent Moon joins the pair on the morning of December 29.

Jupiter lies in Libra when the month begins, but it shifts into Scorpius shortly after midmonth. By the end of December, it appears near a trio of stars north of 1st-magnitude Antares, the brightest star in Scorpius. This trio goes by the name "the crown of the Scorpion."

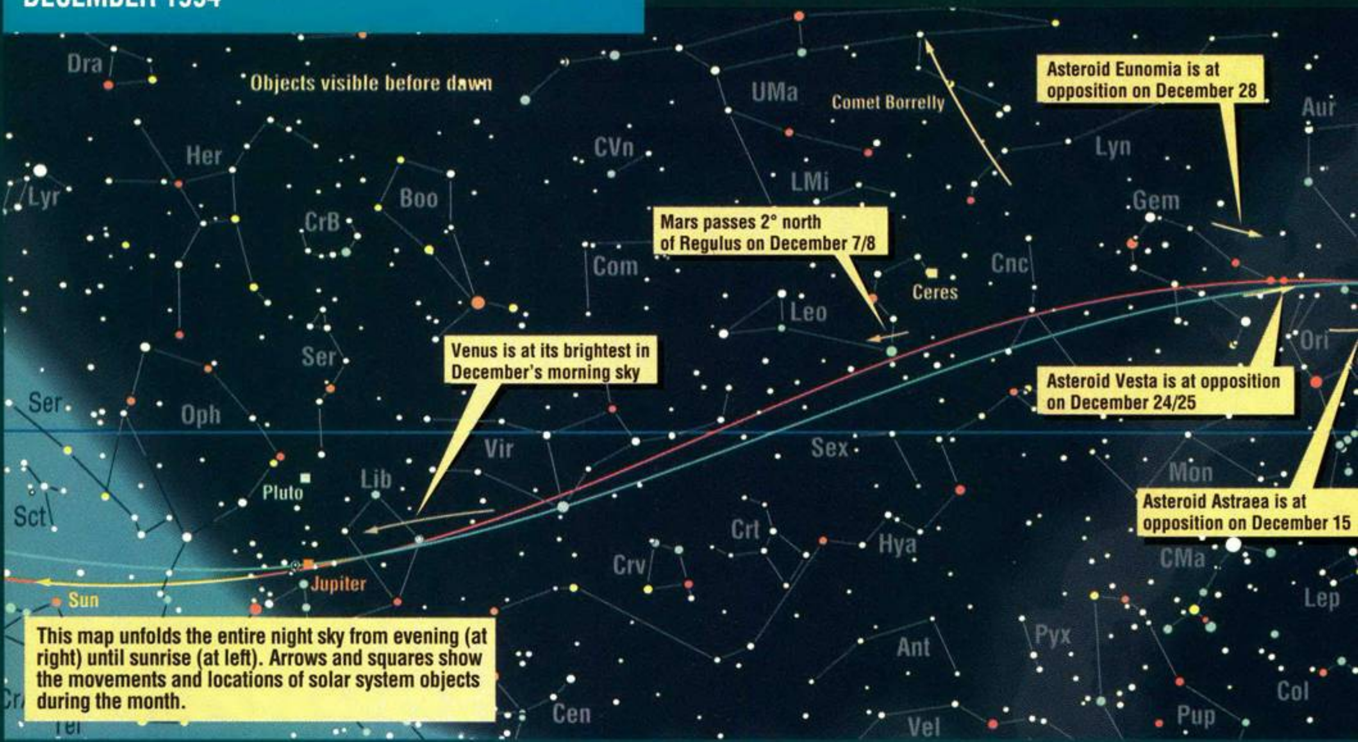
Jupiter isn't much to see through a telescope now. It lies too low in the sky, behind too much of Earth's atmosphere, to show much detail. But this planet and nearby Venus are a joy to watch with the naked eye as twilight brightens into daylight each morning. See how long you can follow them after day breaks.

Mercury and **Pluto** can't be seen this month. Mercury is in superior conjunction, behind the Sun as seen from Earth, on December 13/14. Pluto had its conjunction in November, but it's still too near our line of sight to the Sun to be visible. It will return to the predawn sky in January. □

Deborah Byrd writes and produces the daily "Earth and Sky" radio series. Rick Shaffer is an engineer and writer living in Southern California.

SKY ALMANAC

DECEMBER 1994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Objects visible before dawn
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Mon
Pluto
Lib
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Crt
Hya
CMa
Crv
Jupiter
Sun
Lep
Ant
Pyx
Col
Cr
Tel
Cen
Vel
Pup

Asteroid Eunomia is at opposition on December 28

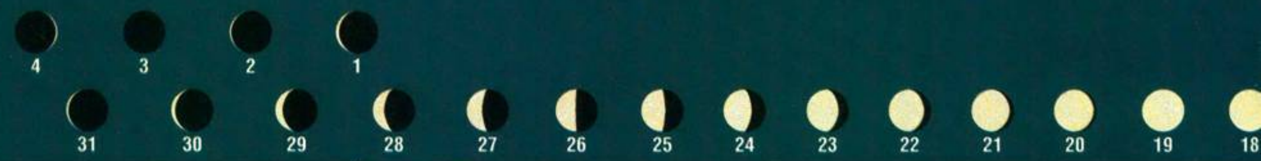
Mars passes 2° north of Regulus on December 7/8

Venus is at its brightest in December's morning sky

Asteroid Vesta is at opposition on December 24/25

Asteroid Astraea is at opposition on December 15

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.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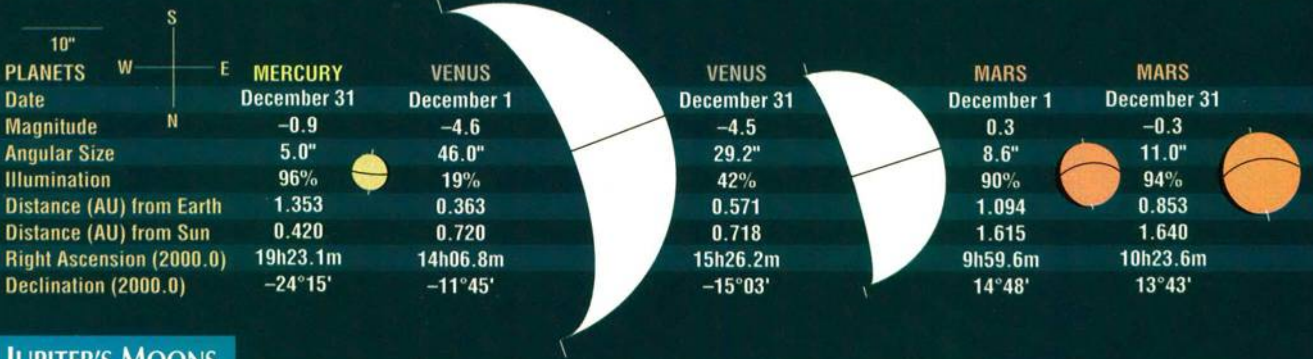
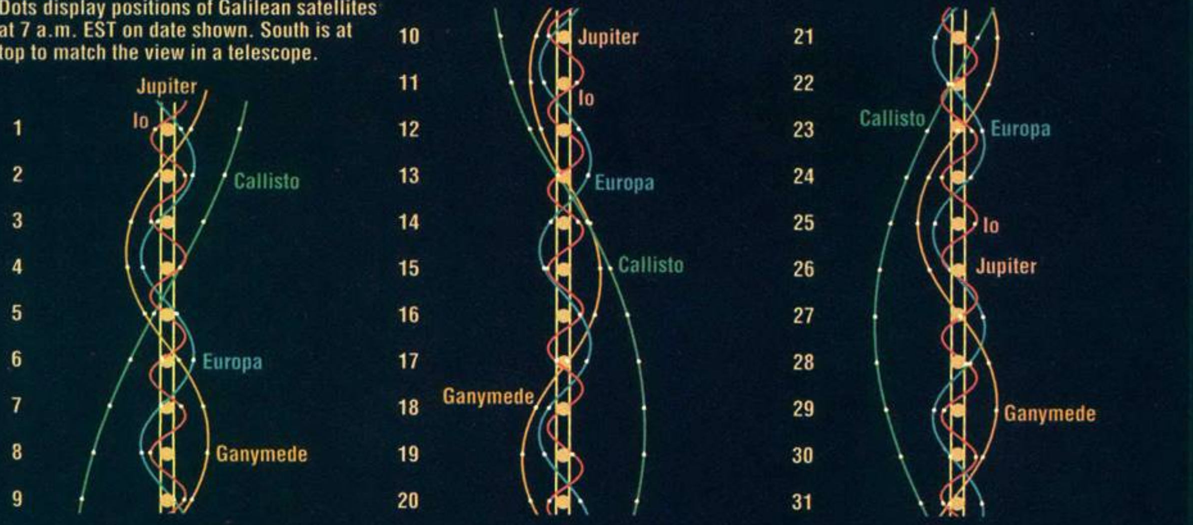
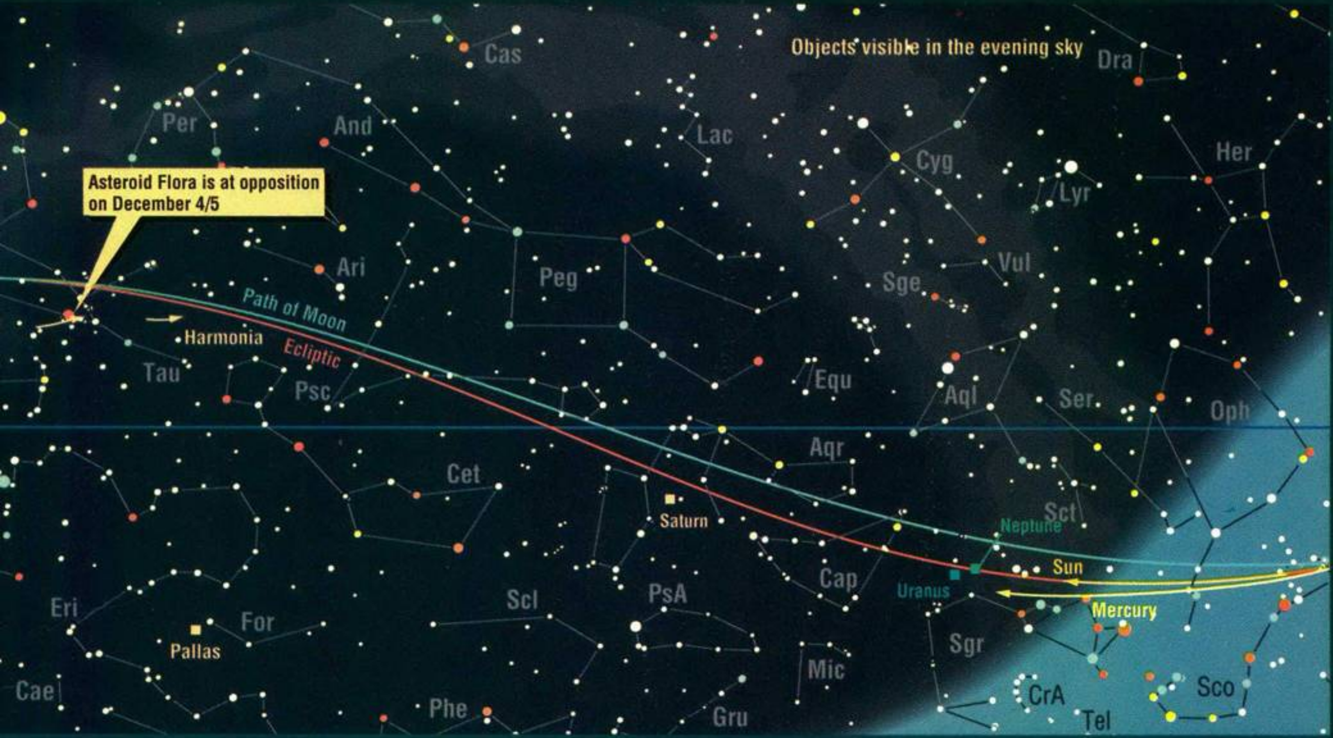
PLANETS	MERCURY	VENUS	VENUS	MARS	MARS
Date	December 31	December 1	December 31	December 1	December 31
Magnitude	–0.9	–4.6	–4.5	0.3	–0.3
Angular Size	5.0"	46.0"	29.2"	8.6"	11.0"
Illumination	96%	19%	42%	90%	94%
Distance (AU) from Earth	1.353	0.363	0.571	1.094	0.853
Distance (AU) from Sun	0.420	0.720	0.718	1.615	1.640
Right Ascension (2000.0)	19h23.1m	14h06.8m	15h26.2m	9h59.6m	10h23.6m
Declination (2000.0)	–24°15'	–11°45'	–15°03'	14°48'	13°43'



JUPITER'S MOONS

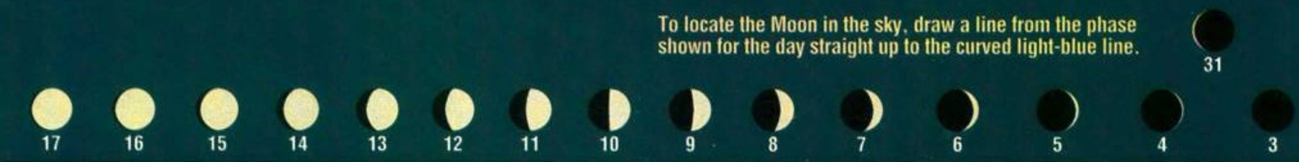
Dots display positions of Galilean satellites at 7 a.m. EST on date shown. South is at top to match the view in a telescope.




Cas
Dra
Per
And
Lac
Cyg
Her
Lyr
Ari
Vul
Peg
Sge
Path of Moon
Harmonia
Ecliptic
Tau
Psc
Equ
Aql
Ser
Oph
Aqr
Cet
Saturn
Sct
Neptune
Sun
Uranus
Cap
Mercury
Eri
Scl
PsA
For
Pallas
Sgr
Mic
Cae
CrA
Sco
Phe
Gru
Tel

Objects visible in the evening sky

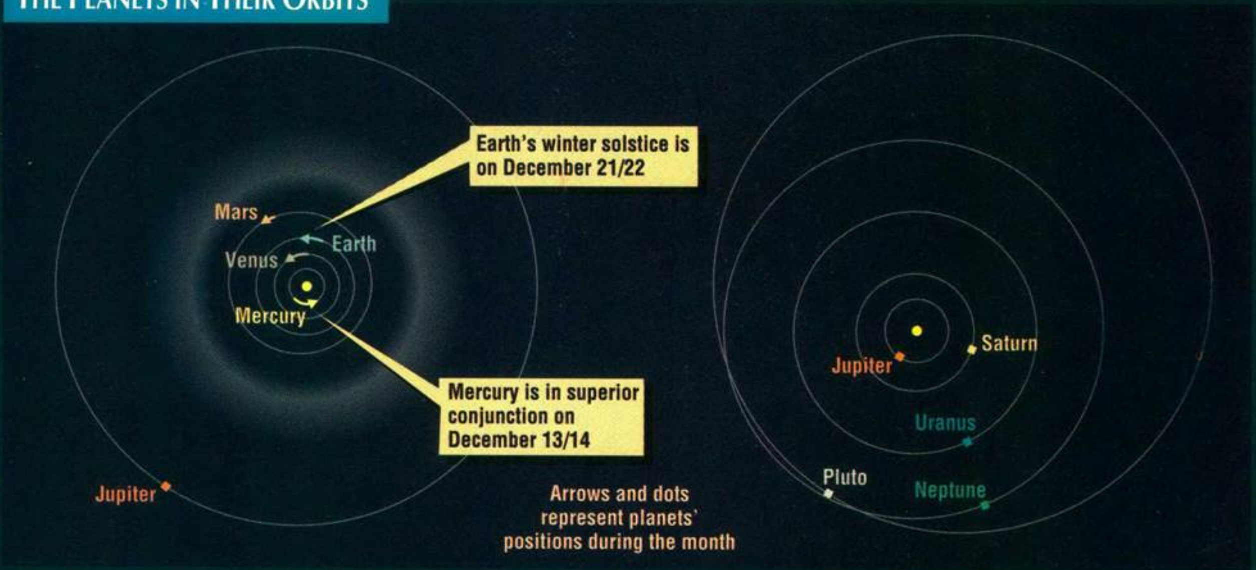
Asteroid Flora is at opposition on December 4/5


31
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
December 15	December 15	December 15	December 15	December 15
–1.7	1.0	5.8	8.0	13.8
31.3"	16.7"	3.4"	2.2"	0.1"
100%	100%	100%	100%	100%
6.288	9.911	20.519	31.029	30.684
5.385	9.686	19.689	30.174	29.811
15h57.2m	22h37.0m	19h46.5m	19h34.8m	15h58.7m
19°40'	–10°42'	–21°41'	–21°05'	–6°57'

THE PLANETS IN THEIR ORBITS


Mars
Earth
Venus
Mercury
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Earth's winter solstice is on December 21/22

Mercury is in superior conjunction on December 13/14

Arrows and dots represent planets' positions during the month

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LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

NGC 55 in Sculptor. 2 hour photo by Andrew Peters (from South Australia) using hypered 2415 film and a 20" f/5 telescope with LUMICON Coma Corrector and LUMICON 2" Easy-Guider. "The Coma Corrector is a terrific accessory," stated Mr. Peters. You may need to use a LUMICON Deep-Sky Filter to see NGC 55 visually.

"I'd Pick The TELE VUE™"

40mm Wide-Field Test, "Astronomy," Aug. 1990, p. 90

Genesis 4" f/5 4 element fluorite	$1885
Pronto 70mm f/6.4 apochromat w/2" diagonal	**$825**
Pronto 70mm f/6.4 w/45° erecting prism	**$725**
Renaissance-SDF 4" f/5.4, brass	**$2095**
Gibralter mount with ash wood tripod	**$495**
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	**$79**
1.8x or 2.5x Tele Vue Barlow Lens	**$89**
2" Giant Barlow - 2x	**$169**
32mm Plossl, widest true field in 1¼"	**$109**
55mm 2" Plossl, widest possible field	**$219**
15mm Wide-Field, 1¼" eyepiece, 65°	**$135**
19mm Wide-Field, 1¼" eyepiece, 65°	**$145**
32mm Wide-Field, 2" eyepiece, 65°	**$239**
40mm Wide-Field, "Rich-Field!" 65°	**$299**
4.8mm Nagler, 82° field, 1¼" eyepiece	**$149**
7mm Nagler, 1¼" eyepiece, 82° field	**$189**
9mm Nagler, 82° field, 1¼" or 2"	**$219**
13mm Nagler, 82° field, 1¼" or 2"	**$249**
12mm Nagler, Type II, 82°, 1¼"/2"	**$249**
16mm Nagler, Type II, 82°, 1¼"/2"	**$289**
20mm Nagler, Type II, 82°, 2" only	**$340**
1¼" Paracorr Visual Coma Corrector	**$159**
2" Paracorr Visual Coma Corrector	**$249**
NEW! 15mm Panoptic 1¼", 68° field	**$199**
NEW! 22mm Panoptic 1¼"/2", 68°	**$249**
NEW! 27mm Panoptic 2", 68° field	**$299**
NEW! 35mm Panoptic 2", 68° field	**$325**

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2.14" **$59.50** 2.60" **$75.00** 3.10" **$99.50**

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2" (1.83" mirror)(see photo above) .. **$165.00**

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"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY February 1991

AMAZING OIII FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90-96% for both O-III lines at 496nm and 501nm.

SEE THE HORSEHEAD!

Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

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BEST for Astrophotography!

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BEST WIDE-BAND FILTER!

"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for ***reflection*** *nebulae."*
Astronomy, Feb. 1991

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Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

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67, 72, 77mm	$79.00	$69.00
82mm	$89.00	N/A

Hypered 2415 film, 36 exp .. **$11.95, $3/$32**

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U.S. Patent 4,473,636

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U.S. Patent 4,448,500

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Pentax 6X7 **add $119;** Pentax 645 **add $139**

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Adapter for Hasselblad **$295,** Mamiya 645**$149**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

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Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**

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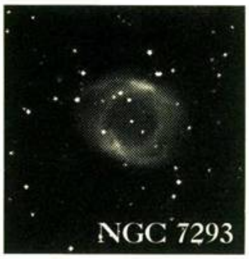
Kodak Ektar 1000 fast, fine grain	24	**$12.95**
Fuji HG400 fine grain color neg.	**24**	**$14.95**
Scotchrome 400, fast slide film	12	**$12.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

How to catch a really big fish.

Pisces and Cetus swim into view these crisp, autumn nights, accompanied by Aquarius. They all offer a sea of deep sky objects that are best seen with Lumicon products.

A very difficult Messier object, Pisces' M74 can be photographed with our Easy Guider. This off-axis guider allows photography at about f/6 with f/10 SCTs. Non-photographers use it as a rich-field viewer for the Double Cluster, Hyades and Pleiades, among other objects. $189.50 for Newtonians, $249 for 8" SCTs, $395 for 10-16" SCTs.*

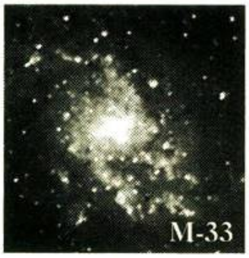
Cetus the Whale is famous for NGC 246. This ghostly nebula is visually stunning with our OIII filter ($99.50 for 1.25" and $199.50 for 48mm*). This filter is ideal for observing the very faintest planetary and diffuse emission nebulae. Our dual axis drive corrector ($249*) is essential to precisely track and shoot long-exposure photos of this planetary nebula.



The Helix nebula in Aquarius is a challenge, despite its brightness and proximity. Our OIII filter ($99.50 for 1.25" and $199.50 for 48mm*), one of the best filters on the market (if not the best) makes viewing this donut of light a real pleasure. Outstanding contrast.

Our 12mm illuminated reticle eyepiece ($109.50*) is the first and most essential accessory for shooting NGC 253 - a very large galaxy just 7 degrees south of Beta Ceti. Its dual crosslines make guiding easier. Works with any Easy Guider.

M2 is a brilliant globular cluster to observe. It's one of over 12,000 objects that are included in our NGC Sky Vector. This computer reads out R.A. and declination coordinates, as well as identifies and guides you to objects. Polar alignment and motor drive aren't required. Just sight two stars to align, and you can find your way around the sky. From $399.*



Hanging above Pisces, M33 is beautiful to view or shoot. The Lumicon Deep Sky Filter ($79.50 for 1.25" and $119.50 for 48mm*) gives you the best chance of seeing spiral detail. Lumicon's hypersensitized film can capture spiral structure on this famous fall galaxy. From just $11.95 per roll.*

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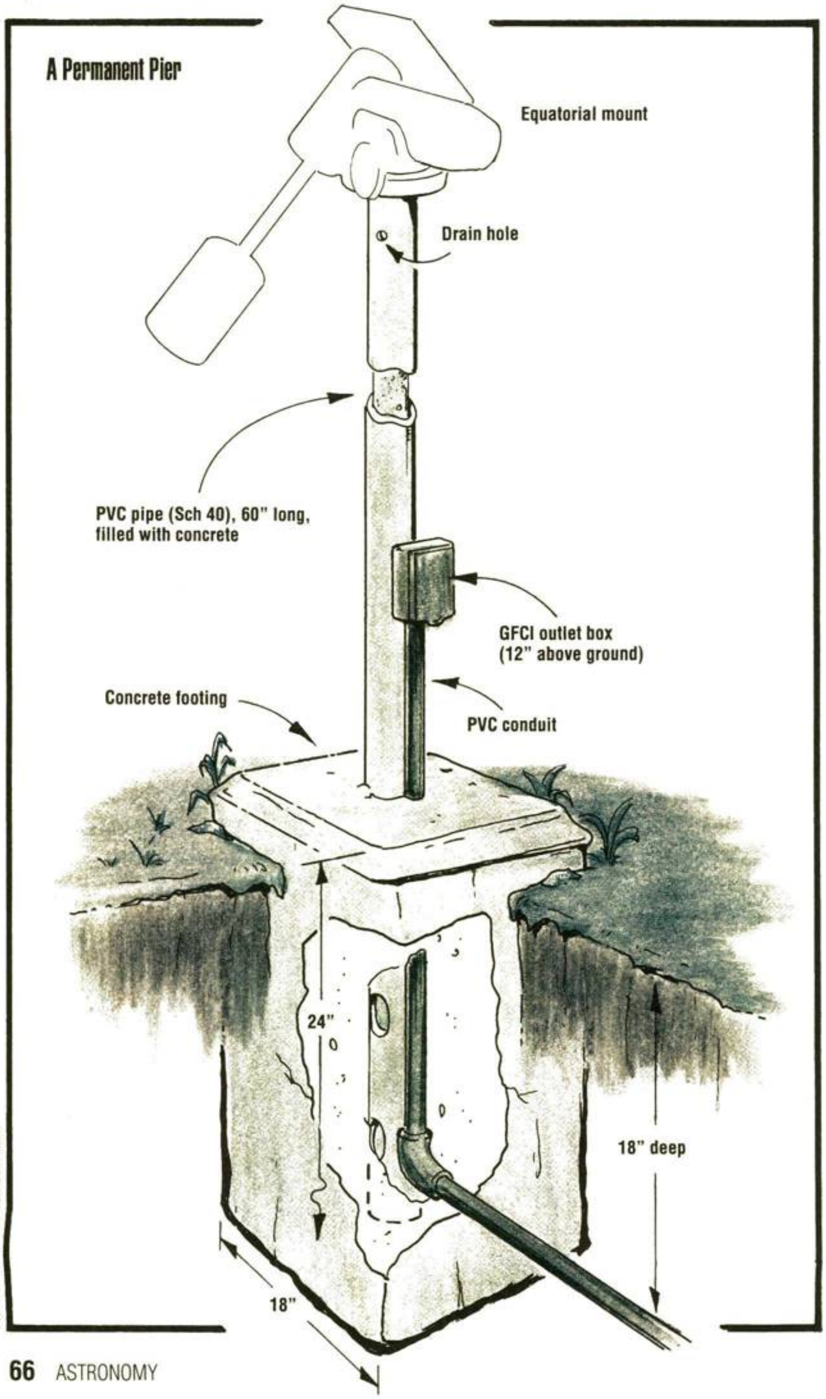
*Taxes, shipping etc. extra. All photos by Jack Marling using these Lumicon accessories.

Improving Your Mount

These do-it-yourself projects will make observing easier, whether you have an equatorially mounted scope or a Dobsonian.

You Don't Need an Observatory

by John Siers



A Permanent Pier

Equatorial mount
Drain hole
PVC pipe (Sch 40), 60" long, filled with concrete
GFCI outlet box (12" above ground)
Concrete footing
PVC conduit
24"
18" deep
18"

ASTRONOMY: Lee Vande Visse

I often thought it would be nice to have an observatory but never found the time and money to build one. Instead, for each astrophotography session, I carried the telescope and its heavy mount out of the garage and into the backyard and then went through the tedious process of polar alignment. After a while, I realized that a permanent pier to hold the scope's mount would provide most of the convenience of an observatory without its expense. The pier prevents having to lug the heavy mount out for each observing session and, more important, saves time because the fixed mount remains polar aligned, always ready for use.

My pier uses 3" PVC drain pipe (the heavy-walled kind used for residential drain, waste, and vent piping, usually referred to as Schedule 40). A 10-foot length costs about $10 and the pipe is easily drilled, filed, or cut with almost any saw.

The 3" pipe was slightly smaller than needed to fit the tripod head of my Super Polaris equatorial mount. I cut a 3"-wide strip from thin-wall PVC pipe and cemented it around the end of the heavier pipe to hold the tripod head snugly with no wobble. Owners of Schmidt-Cassegrain telescopes can adapt larger sizes of PVC pipe to their equatorial wedges.

Choosing a pier height depends on the type of scope and the mount. I found the best height for the pier by placing the scope on its field tripod and adjusting the tripod until the scope was in a comfortable observing position. Measuring from the ground to the base of the tripod head and adding 22" (2" to slide inside the tripod head and 20" to sink in the concrete) gives the length of the pipe needed. An optional step is to drill a few holes (1" diameter) in the bottom 12" of the tube to let concrete seep through during pouring and make the pier more rigid.

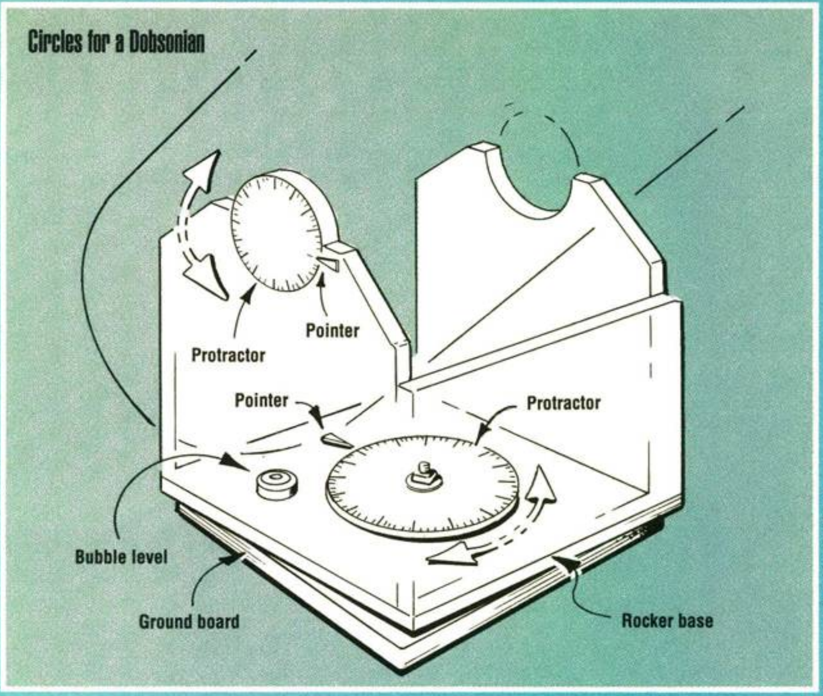
After cutting the tube to length, I dug a hole about 18" across and 24" deep. A hole that size will hold several hundred pounds of concrete (about five bags), enough for a solid footing. Some localities may require a deeper footing due to their frost line. While digging the hole, I also dug a trench from the hole to the house for an electrical cable. I used direct-burial underground (UF) cable, 12 gauge to prevent voltage drop due to the long distance between the pier and house. This cable needs to be at least 12 to 18 inches below grade and may need to be placed in conduit (check your local building code).

I poured a few inches of concrete into the hole, set the PVC pipe in place, embedded an L-shaped piece of PVC conduit next to the PVC pipe, and then filled the hole with concrete. A piece of wood with a hole drilled in it for the conduit kept the concrete from flowing into the trench. A small form made of 2x4s brought the top of the footing several inches above ground level.

The PVC pipe is lightweight, so it needed no bracing while the concrete set. I simply set the proper height above ground level, made sure it was plumb, and then left it alone for several days. Then I attached the outlet box to the conduit and screwed it to the PVC pipe. Next I filled the pipe with concrete to within a few inches of the top. A 1/16" hole in the tube, just above the level of the concrete, drains any water that might get into the top of the tube.

Because the electrical box is outdoors, it should be connected to a ground-fault circuit interrupter (GFCI) circuit breaker or have a GFCI outlet installed. If you don't know how to make the proper 110 VAC connections, hire an electrician to install the electrical service to the pier.

After the concrete had cured for several days, I drilled a hole between each of the leg supports in the tripod head. On a clear night, I took the mount (with the scope and counterweight removed) and set it on top of the pier. After aligning the mount with the north celestial pole using the built-in alignment scope, I drilled holes in the PVC pipe to match those in the tripod cap and secured the mount with short, 1/4-inch-diameter lag screws. I then touched up the polar alignment with the scope in place and the pier was complete. A plastic bag covers the mount when not in use. Now all I have to do is carry out the optical tube and in a minute I'm ready to observe. □


Circles for a Dobsonian

ASTRONOMY: Lee Vande Visse

Add Circles to Your Dob

by Tom McGraw

Finding deep-sky objects with a Dobsonian telescope requires accurate finder charts and the know-how to hop from bright stars to the faint target object. To aid in locating objects, I added setting circles to my Dob. Observing sessions are more fun because now I find more objects with the circles.

A Dob's circles read altitude (up and down) and azimuth (angle along the horizon) rather than right ascension and declination as for an equatorial mount. I find the altitude and azimuth using a planetarium-type computer program. One can also calculate altitude and azimuth from an object's right ascension and declination using simple formulas found in Peter Duffett-Smith's *Practical Astronomy with Your Calculator* (Cambridge University Press, 1988).

Adding setting circles to a Dob is easy. For the azimuth circle, I glued a photocopy of a 360° protractor (a compass rose will also work) to the lid from a gallon paint can. Several coats of clear varnish protect the paper from dew. I drilled a hole through the center of the protractor to fit the bolt holding the rocker base to the ground board. Nuts and washers hold the disk stationary on the bolt while the rocker base rotates. (Replace the bolt with a carriage bolt if it turns as you turn the scope.) A piece of music wire screwed to the base acts as a pointer.

I photocopied a second protractor, enlarging it to the same size as the altitude bearing of my Dob. Before attaching this circle, I carefully leveled the base. First I lowered the tube to horizontal, checking this with a carpenter's level. After taping the altitude bearing to the rocker base to hold this position, I rotated the scope 180° in azimuth. I shimmed the feet of the ground board until the scope was again level. Then I rotated the scope 90° in azimuth and performed the same procedure. Once the base was level, I attached a bubble level (available from hardware stores and camping trailer dealers) to the rocker base.

After removing the tape holding the altitude bearing stationary, I taped the compass rose to the bearing. Then I attached a wire pointer to the rocker base so it read 0° on the protractor. Next I rotated the scope so it pointed straight up and used a carpenter's level to check the tube for plumb. The pointer should indicate 90° but if it doesn't, the protractor can be shifted slightly. I then lowered the scope to horizontal to check that the circle still read 0° and glued the circle to the bearing. Clear varnish protects the paper circle.

When observing, I shim the feet of the ground board until the bubble on the rocker base indicates it's level. Next I point the scope at Polaris (or the north celestial pole to be exact), loosen the nut holding the disk, turn the disk until it reads 0°, and then tighten the nut. These two steps calibrate the circles, making them ready for finding elusive deep-sky objects. □

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Prices Start at $319

Prices include precision helical focuser and 25mm Sirius Plössl eyepiece!

Binoculars for Astronomy

Orion® 8x56 Mini Giants

56mm objective lenses gather over 2.5x the light of ordinary 7x35 binoculars. Perfect for viewing faint celestial objects and daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view. Standard model 33 oz. or Rubber Armored for protection from bumps, weighs 37 oz.

Standard Model #9504 **$159** (4.71)
Rubber Armored Model #9627 **$179** (5.07)

50mm Explorer™ Binoculars

High performance large diameter binoculars with BAK-4 prisms and multi-coatings. Great for both astronomy and daytime observation. Comfortable ergonomic body design. Include case and straps.

7x50 #9306 **$124** (4.44)
10x50 #9308 **$129** (4.44)

Orion 50mm UltraView™

The perfect binocular for eye- and sunglass wearers. Extra-long 23mm eye relief and unique rubber pop-down eyepiece guard allows viewing with or without eyeglasses. Fully multi-coated optics provide high light transmission and maximum contrast compared to standard coated types. BAK-4 prisms. Wide 6.5° field of view. Close focus 16'. Weighs 32 oz. Includes case and straps.

10x50 #9351 **$169** (4.95)
7X50 #9357 **$169** (4.95)

Orion 50mm Vista™

Superb for long distance nature observation and astronomy. The image quality will amaze you even when compared to much higher priced binoculars. Fully multi-coated optics provide high-fidelity true color images without ghosting or other aberrations. Long 16mm eye relief and roll-back eyecups for eyeglass wearers. BAK-4 prisms. Weighs just 28 oz. Includes deluxe hard carrying case, rain shield, lens caps, and straps.

10x50 5.3° field of view #9353 **$219** (5.19)
7X50 6.0° field of view #9355 **$219** (5.19)

Orion® 70mm FMC Giants

The standard for hand-holdable astronomy binoculars. Fully Multi-Coated. 33% lighter, weighs only 58 oz., yet the same brightness and 7mm exit pupil as our 11x80 MC model. Superior 'BCF' body design. Includes: soft rubber eyecaps, tripod mounting adapter, durable hard carrying case, lens caps and straps.

10x70 #9501 **$339** (6.97)
14X70 #9494 **$339** (6.97)

80mm FMC Giant Binoculars

20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable. #9502 **$439** (8.05)

16x80 MC- 45% higher power, excellent for astronomy and daytime observation. Tripod recommended. #9496 **$439** (8.05)

20x80 MC-Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required. #9498 **$439** (8.05)

Orion Standard Series 80mm Giant Binoculars

Sale!

Made in the same factory as name brand models selling for much more! Fully coated optics with multi-coatings and BAK-4 prisms. Smooth center focus design. Soft rubber fold-back eyecups. Include lens caps, straps, and carrying case.

11x80 model Bright 7.1mm exit pupil, 4.2° field of view #9480 **$299** (7.76)

16x80 model 5mm exit pupil, 3.5° field of view. #9482 **$299** (7.76)

SuperGiant™ 100mm Binos

Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus, fully Multi-Coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

Sale!

14x100 #9495 **$899** (14.00)
25x100 #9497 **$999** (14.00)
Shipped by FedEx only.

Observing Aids

Eyepiece & Accessory Cases

With patented unbreakable latches, die-cut foam inserts. (Inside Dimensions shown)

Small Case (shown) 11"x7"x3" #5951 **$17.95** (2.78)

Medium Case 12.5"x9"x5" #5952 **$26.95** (3.36)

Large Case 16"x11"x5" #5953 **$49.95** (5.19)

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.
8" Celestron/Meade SC #4200 **$44.95** (2.98)

Other sizes available for scopes 3.5" to 14"—See our catalog for details.

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.

8" Dew Zappers—fit all Meade & Celestron 8" SCs
DC #3503, AC #3504 **$47.95** (2.98)

10" Dew Zappers—fit all Meade 10" SCs
DC #3506, AC #3508 **$54.95** (2.98)

11" Dew Zappers—fit all Celestron 11" SCs
DC #3510, AC #3512 **$59.95** (2.98)

Scope Saver Telescope Covers

Keep the dust and dew away with these waterproof nylon covers; drawstring closure with cord lock.

8"Model #15130 **$33.95** (2.43)

10"-11" Model Fits Meade 10" and Celestron 11"
#15131 **$39.95** (2.43)

Now available for Deep Space Explorers!
Ask about other sizes.

Observer's Chairs

Standard Model—Adjustable height center column and padded seat.
#5935 **$42.95** (4.70)

Deluxe Model—Built for professional musicians. Extra heavy duty.
#5934 **$94.50** (8.02)

Night Vision Flashlights

An essential accessory for astronomers. Choose from our wide selection.

Nitewriter Pen	#5709	**$9.95** (1.79)
Hands-Free Flex Light	#5707	**$17.95** (2.43)
Starlite LED Flashlight	#5714	**$24.95** (2.43)
Celestron LED Flashlight	#5720	**$21.95** (2.43)

Filters

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.

For 8" SCs #7713 **$144** (4.05)
For 10" SCs #7715 **$162** (4.05)

NEW! *Solar glass filters for Deep Space Explorer reflectors. Many other sizes available—see our free catalog for details.*

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664, 1.25" #5662 **$15.95** (2.43)

Color Eyepiece Filters

Made from absolutely the highest quality photographic-grade precision-ground optical glass, anti-reflection coated. Ideal for contrast-enhancing planetary and lunar observations and photography with any telescope. The black anodized, machined aluminum cells thread into any standard eyepieces, or into our universal camera adapters.

.965" Basic Set of 4 Filters #80A Blue, #58 Green, #25 Red, #15 Yellow. #5510 **$49.95 set** (2.98)

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow.* #5514
1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.* #5516
1.25" Advanced Set of 4 *#8 Light Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green.* #5570
$54.95 each set (2.98)

Deluxe Set of 8 Filters for 1.25" Includes all the filters in our basic and expansion filter sets. #5517 **$99.95 set** (3.45)

Full Set of 12 Filters for 1.25" Includes Basic Set, Expansion Set, Advanced Set. #5575 **$144 set** (3.67)

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow. #5513 **$89.95 set** (2.98)

Individual .965", 1.25" & 2" Filters- Many colors available, see our catalog for details.

SkyGlow™ Light Pollution Filters

The finest available, SkyGlow™ filters from Orion make detailed deep-sky observing possible from light polluted city and suburban locations. Sophisticated multi-layer technology actually absorbs light pollution! Greater blocking and higher transmission than competitive models. See catalog for details..

SkyGlow UltraBlock Filters–Visual Only

For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter–fits 1.25" eyepieces. #5654 **$99.95** (3.45)
2" UltraBlock Filter–fits 2" eyepieces. #5657 **$149** (3.67)
.965" UltraBlock Filter–fits .965" eyepieces. #5655 **$79.95** (2.98)
SC UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes. #5656 **$149** (3.67)

SkyGlow Broadband Filters—Photographic and Visual

For use in slightly to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces. #5660 **$79.95** (3.45)
SC Broadband Filter–fits rear cell of Meade & Celestron SC scopes. #5658 **$99.95** (3.45)
52mm Broadband Filter–For 52mm camera lenses. (Adapter rings available for other diameters.) #5668 **$87.50** (3.45)
2" Broadband Filter–fits 2" eyepieces. #5659 **$119** (3.45)
.965" Broadband Filter–fits .965" eyepieces. #5661 **$49.95** (2.98)

Accessories

Call Toll-Free for Our Huge 100 Page Catalog and See Even More!
Orion Accessories are absolutely guaranteed to be the finest quality available. Compare them side-by-side with "famous name" products! We buy direct from many of the same sources, always specify the highest quality and pass along the savings to you! 100% satisfaction guaranteed!

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.
.965" #5268 **$27.95** (2.98)
1.25" #5264 **$29.95** (2.98)
Hybrid 1.25"/.965" #8782 **$29.95** (2.98)

Variable Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.
#5262 **$39.95** (2.98)

Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.
#7012 **$64.95** (2.98)

Extension Cable for Slow Motion Control

12 3/4" flexible cable, for tracking at high powers. Buy 2, one for each axis.
#5014 **$19.95 ea.** (2.43)

Tele-Extenders for SC Scopes

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.
Standard Tele-Extender #5125 **$29.95** (2.98)
Variable Tele-Extender #5127 **$39.95** (2.98)

T-Adapters for SC and MAK

Threads to rear cell of telescope, requires t-ring for your camera model.
for SC #5116 **$26.95** (2.98)
for C-90 #7115 **$34.95** (2.98)

T-Rings for all 35mm Cameras

Available for many different camera types, call toll-free or see our catalog for your particular model.

45° Erect Image Diagonal Prisms

See the world as it really is with Orion's 45° erect image diagonal. Ideal for all refractors and compound telescopes used for terrestrial viewing.
1.25" Diagonal #8790
.965" Diagonal #8791
Hybrid 1.25"/.965" Diagonal #8792
$44.95 (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagonals let you view at a right angle from the direction your telescope is pointing. The image is backward. Ideal for refractors and Schmidt-Cassegrains used for astronomical viewing.
1.25" Star Diagonal #8763 **$49.95** (2.98)
.965" Star Diagonal #8761 **$29.95** (2.98)
Hybrid 1.25"/.965" Star Diagonal #14008 **$33.95** (2.98)

Orion Ultra™ 2" Diagonals

Your SC or refractor deserves the finest. Both models are the finest optical quality and use the best coatings available.
2" Prism Diagonal–Absolutely the finest quality multi-coated 2" prism for highest light transmission.
For refractors #8770
For Schmidt-Cass. #8771 **$219** (4.71)
2" Mirror Diagonal– Affordable, high-quality first-surface optical flat star diagonal.
For refractors #8773
For Schmidt-Cass. #8772 **$109** (3.45)

Sky Wizard™

Electronic Finder & Sky Catalog

SAVE $50 On Any Sky Wizard when purchased with any telescope installation package!

Let Sky Wizard do the work, while you relax and have fun observing!

- Find any celestial subject in 15 seconds!
- One minute setup — no polar alignment or levelling.
- Observe hundreds of objects in a few hours!
- For ANY telescope, with or without a motor drive. *Even altazimuth or Dobsonian scopes!*
- Digital display of celestial coordinates (RA & Dec).
- Built-in electronic sky catalog — find subjects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a single 9v battery. Weighs just 6 oz!

Sky Wizard Model 1
Includes the Messier Deep Space Catalog of 110 objects, 28 bright stars, and the planets. #7801 **$199** (4.11)

Sky Wizard Model 2
Huge 2100+ object database, plus a user catalog to store 27 objects of your choice. #7802 **$319** (4.44)

Sky Wizard Model 3
Gigantic 10,000 object database, expanded subject descriptions, RS-232 port. #7803 **$469** (6.78)

Complete system requires Sky Wizard Model 1, 2 or 3 and a telescope installation package, sold separately.

Installation Packages
Includes 2 encoders, all required mounting hardware and brackets, connecting cables, and complete illustrated instructions.
Installation packages are available for most telescope models. Call for details.
starting at **$177** (5.29)

Encoders and cables also available separately for custom installations. Call for details.

Orion Off-Axis Guider

Allows you to observe a guide star during photography. Multi-coated.
#5144 **$74.95** (3.45)

Orion UltraGuider

Wide-range lateral prism adjustment; precision helical focusing; adjustable camera focal plane position.
#5139 **$129** (4.19)

110v Motor Drive for Refractors

Fits Orion equatorial mounts, many others. Plugs into any standard AC outlet.
#17001 **$74.95** (3.95)

12 Amp Hour Porta Pac Battery

Ideal for high power-consuming accessories. With carrying case. Weighs only 10 lbs.
#2354 **$109** (8.97)

Eyepieces

See Our Huge 100 Page Catalog for Many More! Including a Fantastic Selection of Name Brand Eyepieces!
2
3b
3c
3a
5
1
40mm
✧Sirius™
Plössl

1 ✧ *Sirius*™ *Plössl 1.25" Eyepieces*

Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!

You could pay nearly twice the price for "famous name" Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces!
Sirius Plössls are top-quality, 50° apparent field (43° 40mm) eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of telescopes. The Classic 4-element Plössl design is renowned for its fantastic performance and has become the standard by which all other eyepieces are compared.

The Fully Magnesium fluoride coated optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

26mm #8732, *17mm* #8734,
10mm #8736, *7.5mm* #8738 **$57.95 ea.** (3.45)
40mm #8730 **$79.95** (3.67)
Case only #5911 **$12.95** (2.19)

SPECIAL OFFER–Buy Two or More and Save!
- *Any 2 .... $10 off (Save $5 ea.)*
- *Any 3 .... $30 off (Save $10 ea.)*
- *Any 4 .... $60 off (Save $15 ea.)*
- *ALL 5 .... $85 off (Save $17 ea.)*

*Bonus—**Free case** with purchase of 2 or more!*

2 Orion 5-Element Ultrascopic™ Eyepieces

With Superb Ultra™ Multi-Coatings!

Made for Orion by Japan's finest lens maker, Ultrascopic eyepieces yield the highest contrast, greatest light transmission and best overall image fidelity obtainable. With a superior 5-element design and Ultra™ Multi-Coatings on *every* surface, they achieve a level of performance "name brand" 4-element models can't match. Wide 52° flat field of view. Removable contoured rubber eyeguard. The 5mm and 3.8mm feature advanced 7-element designs which yield surprisingly long eye relief. Absolutely guaranteed to knock your socks off!

Medium-High Power 5-element
20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572 **$89.95 ea.** (3.45)

Wide Field 5-element **25mm** #8564 **$99.95** (3.45)
30mm #8562 **$109** (3.45)
35mm #8560 **$119** (3.45)
High Power 7-element *—Long Eye Relief*
5mm #8574, **3.8mm** #8576 **$99.95** (3.45)

3 Orion Explorer™ Multi-Coated 1.25" & .965" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Three different optical designs are incorporated to maximize efficiency in the various focal lengths. Black anodized, internally blackened, threaded for filters (except 40mm .965").

b *1.25" Orthoscopic*
5mm #8500, **7mm** #8502, **9mm** #8504, **12.5mm** #8506, **18mm** #8524, **25mm** #8526
$57.95 each (2.98)

c *1.25" Kellner*
6mm #8536, **9mm** #8538, **12mm** #8540, **18mm** #8508, **25mm** #8510, **40mm** #8512
$47.95 each (2.98)

a *.965 Orthoscopic*
5mm #8580, **7mm** #8581, **9mm** #8582, **12.5mm** #8583 **$49.50 each** (2.98)

a *.965 Kellner & Achromatic Huygenien*
K 18mm #8584, **K 25mm** #8585, **AH 40mm** #8586
$37.50 each (2.98)

Illuminated Reticle Eyepieces

A necessity for long exposure astrophotography and very useful for polar alignment.

12.5mm Plössl Illuminated Reticle 1.25"
Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.
#8484 **$119** (3.45)

9mm Orthoscopic Illuminated Reticle 1.25"
Adjustable brightness illuminator. 'Bull's-eye within crosshairs' reticle. Needs 2 SR-44 batteries, not included.
#8488 **$129** (3.67))

12mm Kellner Illuminated Reticle 1.25"
Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.
#8482 **$74.95** (3.45)

12mm Kellner Illuminated Reticle 1.25"
Same as #8482 above except has a wireless illuminator. Needs 2 SR-44 batteries, not included.
#8481 **$99.95** (3.45)

SR-44 Batteries (pkg. of 2) #2360 **$5.95** (1.79)

5 UltraZoom™ 7–21mm

The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.
#8556 **$179** (3.67)

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.
.965" #8740 **$39.95** (2.98)
1.25" #8746 **$46.95** (2.98)
2" #8724 **$89.95** (3.95)

Ultrascopic 2x Fully Multi-Coated Barlow
3-element Ultrascopic lens for superior images and precise color correction. Fully multi-coated optics, black anodized barrel. 1.25 barrel.
#8750 **$64.95** (3.45)

VariPower 2-3x Barlow
Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.
#8748 **$59.95** (3.45)

Shorty Barlows
The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly and 3x magnification when positioned before the diagonal on a refractor or SC. Will work in all telescopes, including those where longer barlows won't work.
.965" #8710 **$44.95** (2.98)
1.25" #8711 **$54.95** (3.45)

Quality Components for Building or Upgrading

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced! *See catalog for pricing.*

Standard Primary Mirrors

Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/4.5, 12.5" f/6.

Pyrex Low Expansion Mirrors

Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with standard or 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

Elliptical Secondary Mirrors

Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with standard or high reflectivity Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis.
See catalog for pricing.

6x30 Achromatic Finder Scopes

6x30mm—Same unit used on $1000+ "big name" telescopes. With 2-ring metal bracket, fits scopes 6"-12".
#13023 (white) **$49.95** (3.41)

6x30mm Right Angle—90° prism for right-angle viewing. Includes bracket.
#13021 (white) **$74.95** (3.41)

Large Aperture Finder Scopes

These are high-quality finders at incredibly low prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White or black enameled metal tube. (Mounts sold separately.)

8x50mm—2.7x light grasp of 30mm models. Bright 6.25mm exit pupil.
#7090 (white) #7094 (black) **$69.95** (3.41)

8x50mm Illuminated—Wireless illuminator with adjustable brightness.
#7092 (white) #7096 (black) **$99.95** (3.41)

9x60mm — 44% more light grasp than 50mm models.
#7091 (white) #7095 (black) **$99.95** (3.41)

9x60mm Illuminated—Wireless illuminator with adjustable brightness.
#7093 (white) #7097 (black) **$139** (3.41)

Superb Dovetail Aluminum Mounts for 50mm and 60mm Finder Scopes

Instantly install or remove your finder, without tools, without disturbing alignment! Black anodized, fits any scope 6" and over including Celestron & Meade SCs. *(pictured above)*
8x50mm bracket #5040 **$37.50** (2.45)
9x60mm bracket #5041 **$44.50** (2.98)
Extra dovetail mounting plate #5050 **$12.95** (2.19)

Low-Profile Helical Focusers

Economical yet precise focusing. Ideal for fast optical systems. Cast aluminum base with threaded machined aluminum inner tube.
1.25" #13014 **$39.95** (2.45)
2.0" #13016 **$64.50** (2.98)

Rack-and-Pinion Focusers

Finest in their class! Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.
1.25" #13007 **$59.95** (2.98)
2.0" includes 1.25" adapter.
#13003 **$99.95** (3.95)

MONEY-BACK GUARANTEE
If you are not completely satisfied with your purchase from Orion, for any reason,
100% Satisfaction
just return it in new condition within 30 days after delivery for a prompt refund.

IT'S EASY TO ORDER!

- Call toll-free and charge to your MasterCard, Visa or Discover Card or send your personal check to order by mail.
- California residents add 7.25% sales tax (8.25% in Santa Clara and Santa Cruz Counties, 8.5% in San Francisco).
- Shipping & handling charge for UPS Ground or US Mail to lower 48 United States are listed in parentheses after each price. We ship to U.S. and Canada only.
- We expected the prices in this ad to be accurate for November 1994 at the time of our advertising deadline in September. Please call our toll-free number for current pricing and to receive our latest catalog. Prices are subject to change or correction without notice.

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READER REPORTS SPECIAL

JUPITER'S EMBATTLED CLOUDTOPS

Comet Shoemaker-Levy 9 threw a great party for backyard observers. Here's proof.

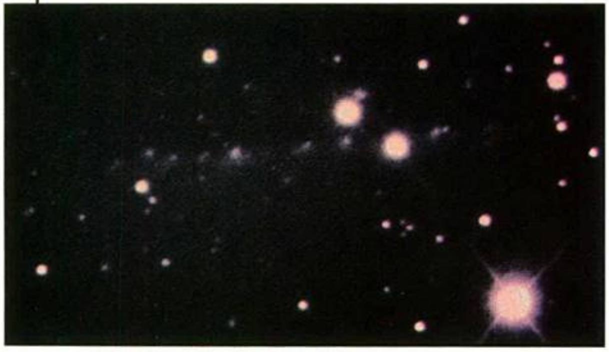
by David J. Eicher

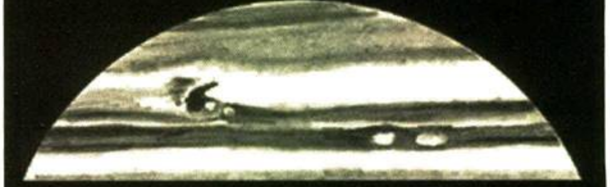
They thought it might be impossible, perhaps difficult at best. But when the 23 major fragments of Comet Shoemaker-Levy 9 started smashing into Jupiter's clouds, it was easy. Backyard astronomers all around the world armed with telescopes as small as two inches in aperture watched Jupiter as it accumulated bruises. It was the week of July 16-22, 1994, and it was a week astronomers will not forget for a long time to come.

As the national media focused on the latest explosive results and scientists sat glued to each morning's press conference, amateur astronomers delighted at simply soaking in the views of Jupiter's southern hemisphere and recording it on film, with paper and pencil and through electronic CCD cameras and image-processing

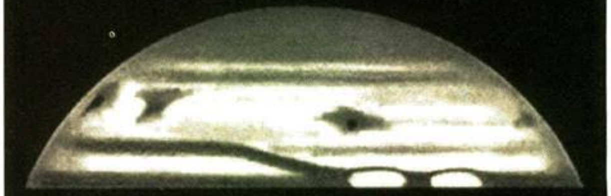
COMET SHOEMAKER-LEVY 9
by James McGaha

(24-inch f/5 reflector, HPC-1 CCD camera, taken on May 5, 1994)

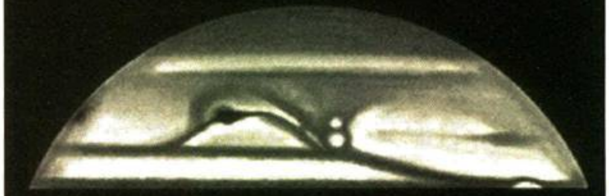




July 16, 1994 (CMII=132.6 deg.)



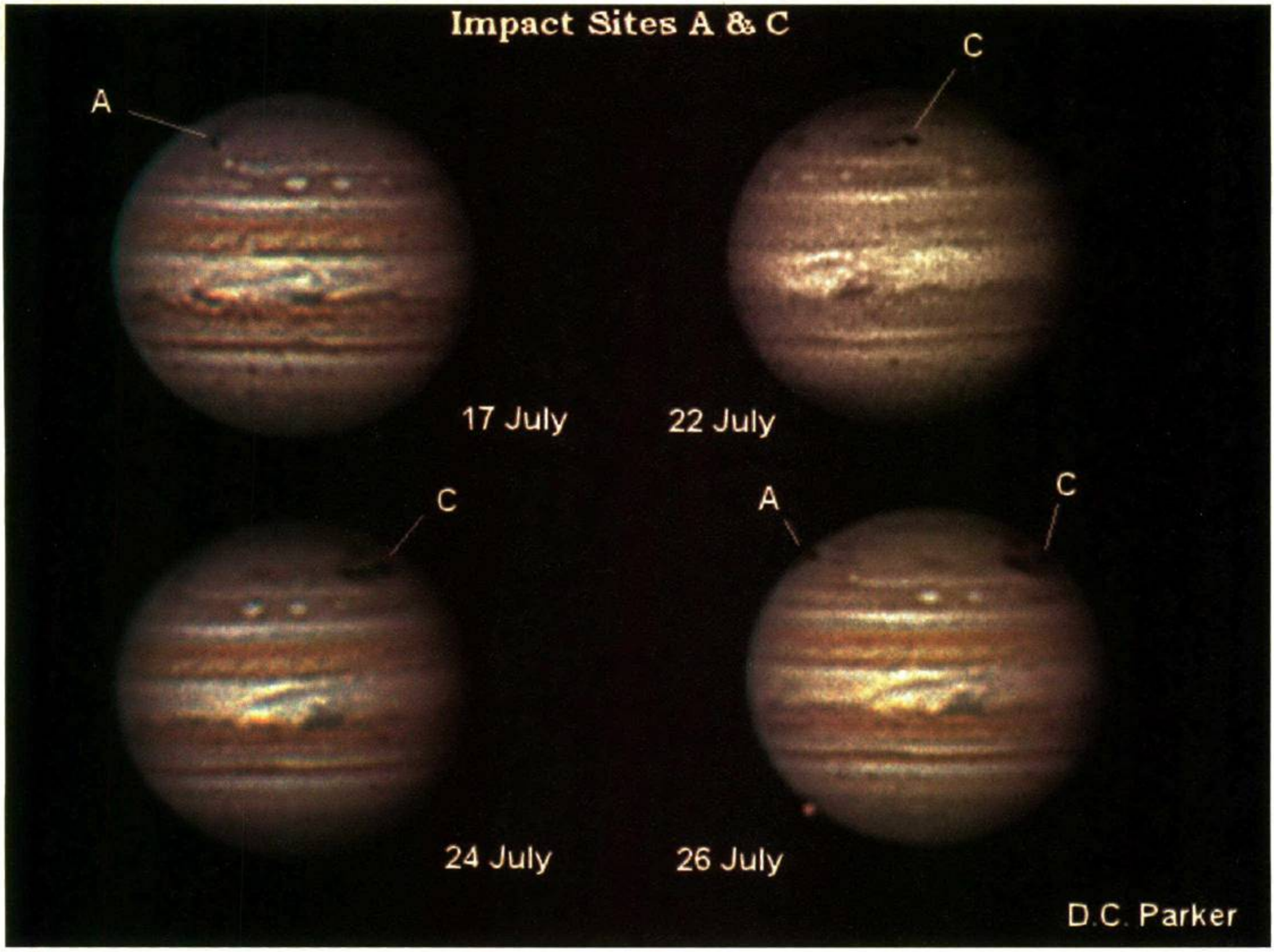
July 19, 1994 (CMII=139.4 deg.)



July 31, 1994 (CMII=101.6 deg.)

THE EVOLVING JOVIAN LOOK
Sketches by Jeffrey D. Beish and Carlos E. Hernandez

(Top: Jeffrey D. Beish, 16-inch f/7 reflector at 225x and 382x at 7:35 p.m. EDT sketched on July 16, 1994; center: Carlos E. Hernandez, 16-inch f/7 reflector at 360x at 9:25 p.m. sketched on July 18, 1994; bottom: Carlos E. Hernandez, 16-inch f/7 reflector at 382x at 8:20 p.m. EDT sketched on July 30, 1994)

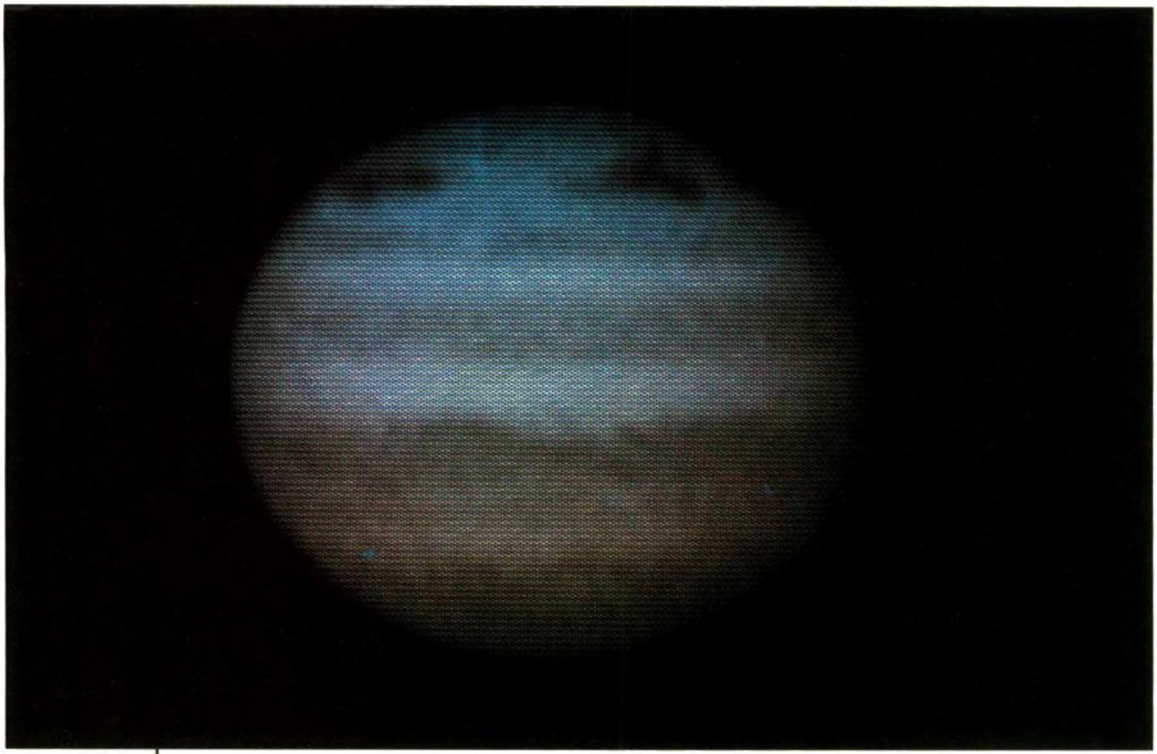

Impact Sites A & C
A
C
17 July
22 July
C
A
C
24 July
26 July
D.C. Parker

CRASH SITES A AND C
by Donald C. Parker

(16-inch f/7 reflector, Lynxx CCD camera, taken on July 17, 22, 24, and 26, 1994)

A COMET-CRASH CROWD ASSEMBLES
by Ralph Merletti

(Taken on July 20, 1994, at Riverside Community College, California)

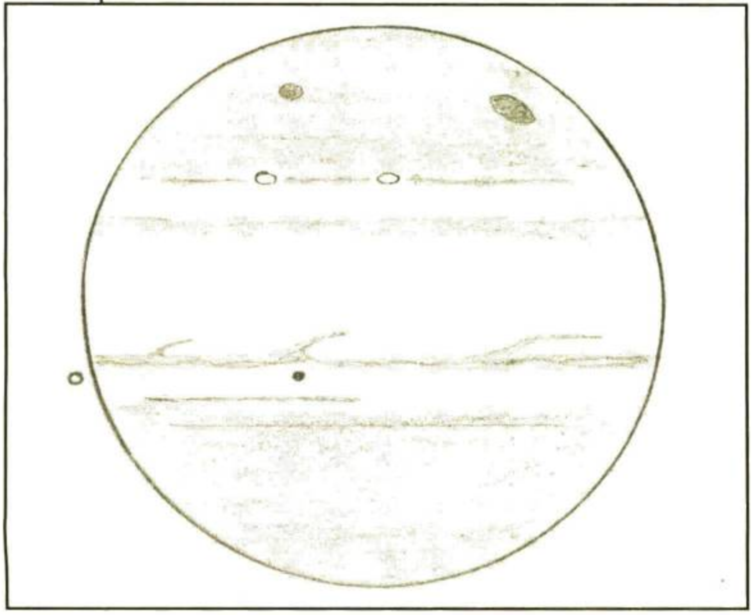


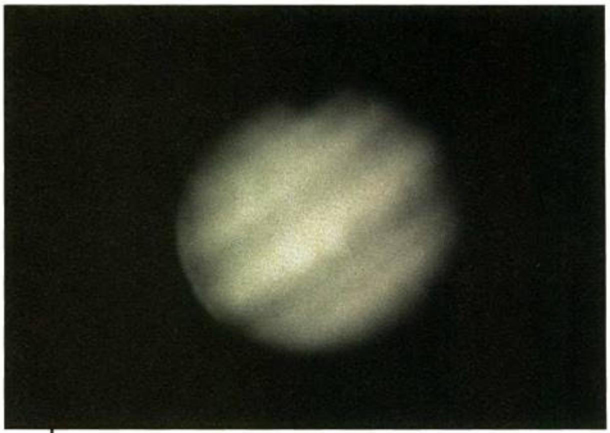
A HI-RES, COLOR VIDEO VIEW (LEFT TO RIGHT: SITES K/W, L, AND G/D)
by Ronald E. Royer, Dave Phelps, and Rick Sorensen

(12.5-inch reflector, Starlight Xpress CCD camera, taken on July 25, 1994)

IMPACTS, SHADOWS, AND FESTOONS (L TO R: SITES K AND C)
Sketch by Randy Pakan

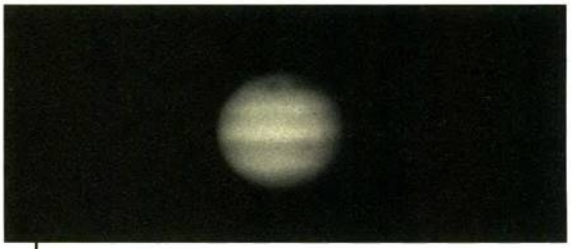
(16-inch reflector at 180x, sketch made at midnight EDT on July 21, 1994)





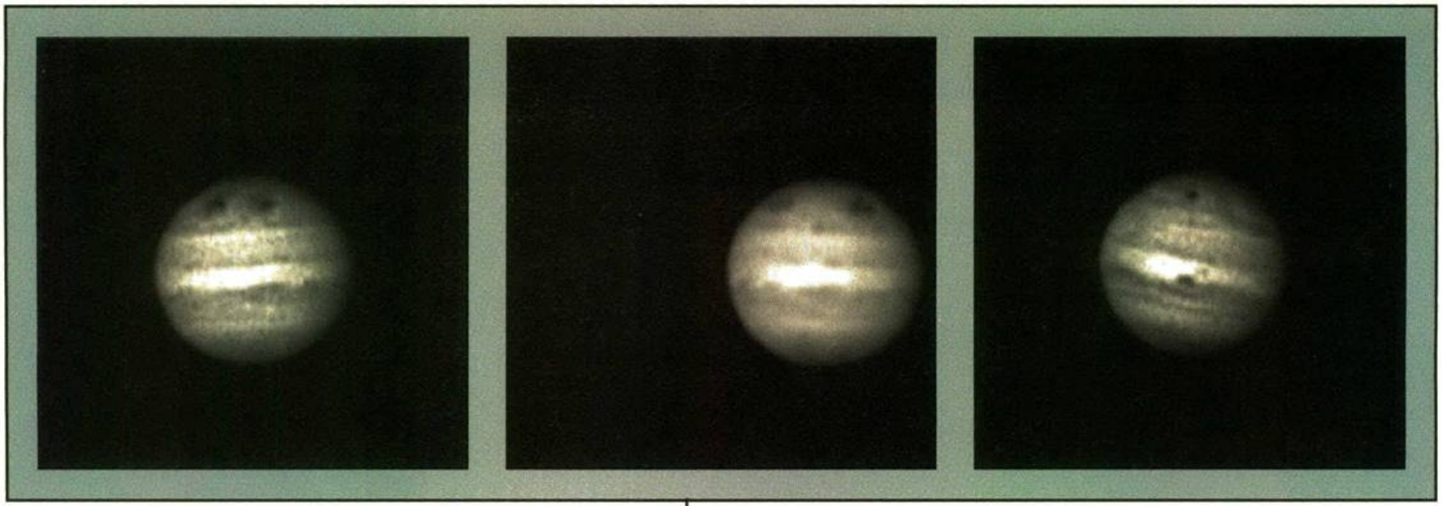
VIDEO CAPTURES THE IMPACT (SITES K AND W ON LIMB)
by Thomas A. Dobbins

(10-inch reflector at f/34, Starlit Technology CCD videocamera with Schott KG1 filter, taken at 9:14 p.m. EDT on July 23, 1994)



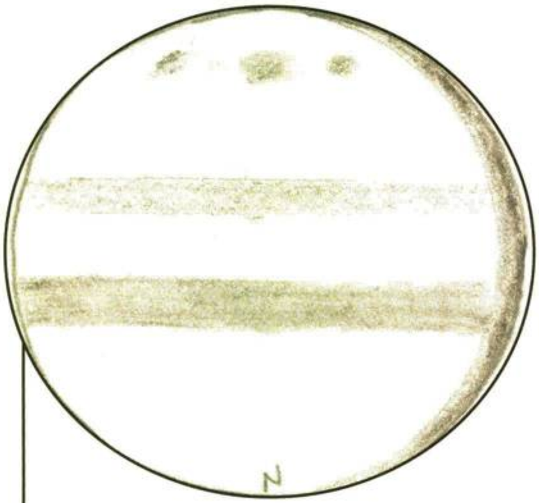
A REFRACTOR'S GLIMPSE OF THE ACTION (L TO R: SITES A,C, AND K/W)
by Chris Cook and Jim Janusz

(6-inch refractor at f/150, T-MAX 100 film, 1.5-second exposure taken on July 28, 1994)



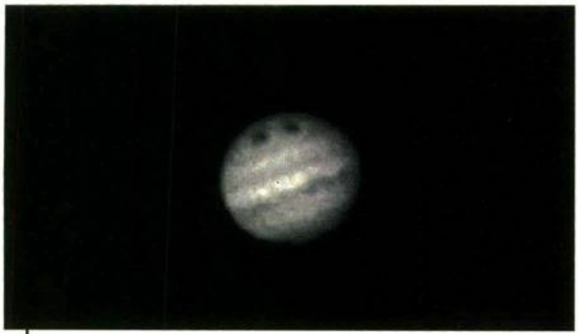
ONE-COLOR CCD CAPTURES THE SPOTS
by Gregory Terrance

(16-inch reflector at f/15, ST-6 CCD camera, taken on July 18, 1994, left, July 21, 1994, center, and July 25, 1994, right)



THE 60MM VIEW
(L TO R: SITES G/D AND L)
Sketch by Ralph E. Mackenstein

(60mm refractor at 72x, sketch made at 9:30 p.m. EDT on July 19, 1994)



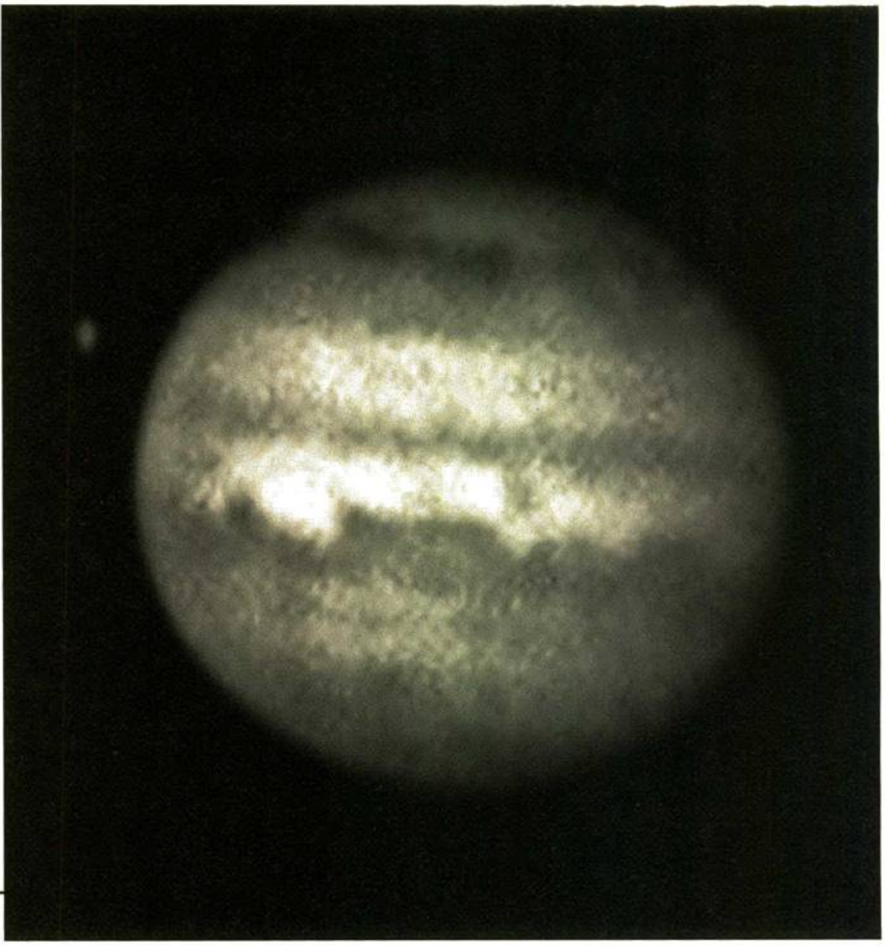
"THEY'RE PLAIN AS DAY"
(L TO R: SITES L AND G/D)
by Ronald W. Kohl

(20-inch Cassegrain, STAR I CCD camera, 0.1-second exposure taken at 9:35 p.m. EDT on July 19, 1994)

software. The planet was high in the sky as the sky began to darken each night and remained above the horizon for several hours before setting in the west. All of the strikes occurred out of view from Earth but the planet's rapid rotation carried them into view after a few minutes. Thereafter each spot remained visible for some five hours before rotating out of view. As more and more pieces of the comet struck the same latitude but different longitudes of Jupiter's southern hemisphere, a game evolved of attempting to keep the spots straight. After a few days, as the spots changed their appearance and new spots appeared, it became difficult to keep them sorted out.

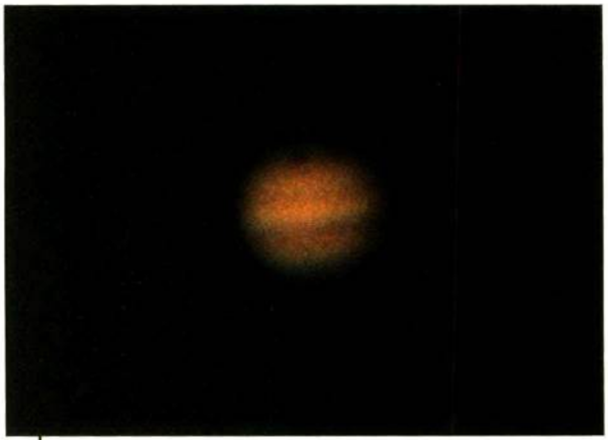
But such trivial problems didn't enter the mind at the outset. Some viewers even tried to spot Jupiter and its cloud damage in the daytime. From Miami, Florida, Jeffrey D. Beish and Carlos E. Hernandez filed the first amateur observation of the spot created by fragment A at 7:35 p.m. EDT on July 16, less than four hours after the impact. Beish, Hernandez, and Donald C. Parker of nearby Coral Gables are Mars Recorders for the Association of Lunar and Planetary Observers, and they produced some of the finest eyepiece drawings (Beish and Hernandez) and CCD images (Parker) of the comet crash sites (see pages 70, 71, 76, and 77). Of their "discovery" observation, made with a 16-inch f/7 reflector at 225x and 382x, Beish and Hernandez say the spot "appeared as a dark, crescent-shaped albedo feature at the southern border of the South South Temperate Belt and within the South South Temperate Zone. A dark ray system preceded the spot [as it rotated] and a pair of small, bright ovals followed it."

Beish and Hernandez were the first among thousands who saw the A spot and others that followed. Along with almost all backyard observers who had a clear sky, I ventured out and trained an 8-inch SCT on Jupiter. After swatting a mosquito and focusing carefully, I saw two dark blotches, A and E, plain as day. It



Crash Sites L, G, and S
by Gregory Terrance

(16-inch reflector at f/15, ST-6 CCD camera, taken on August 22, 1994)



Twin Bruises, L and G/D, Mark Jupiter
by A. Vincent

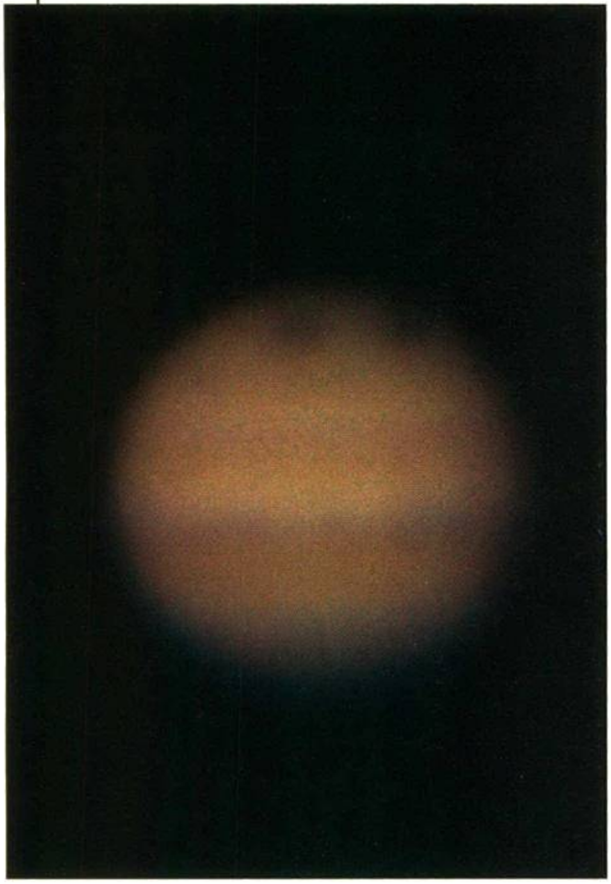
(8-inch SCT, FujiSuper HG 400 film, 1-second exposure, taken on July 20, 1994)

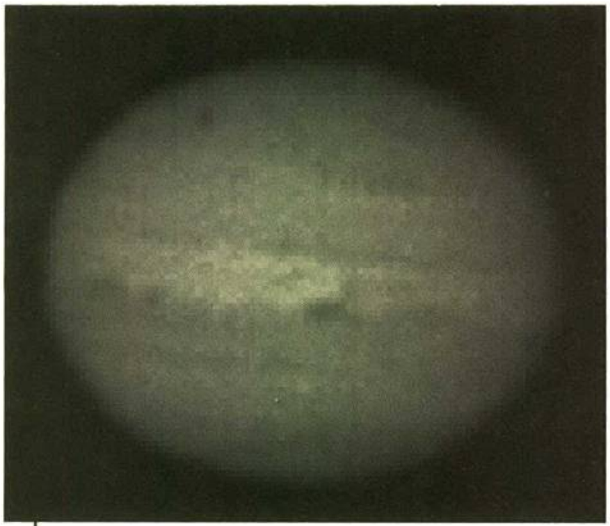
Crash Sites H and E with the Red Spot
by Mark Schmidt

(14-inch SCT at f/95, Ektachrome 100 film, 3-second exposure taken on July 27, 1994)

BLACK EYES E AND A DOMINATE THE PLANET
by Ed Couture

(11-inch SCT, Fuji Reala 100 film, 5-second exposure taken on July 19, 1994)



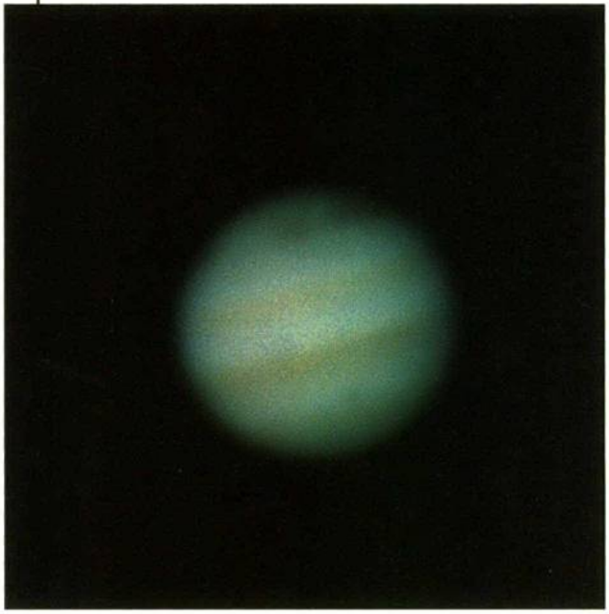


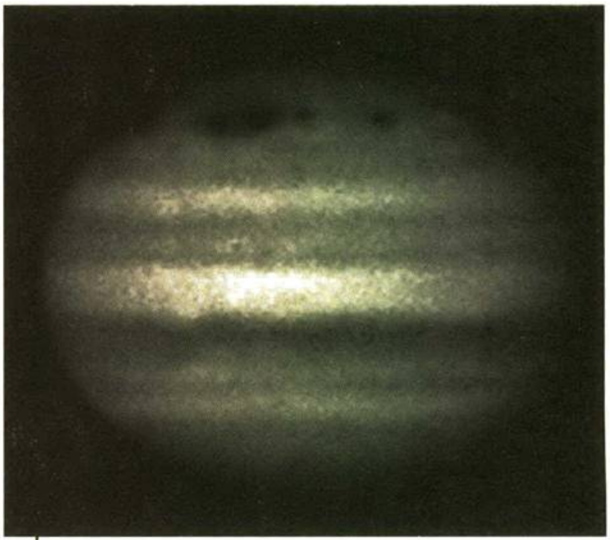
CRASH SITE E HOSTS EUROPA'S TRANSIT SHADOW
by Myron E. Wasiuta

(10-inch reflector at f/24, Electrim EDC-1000 CCD camera, Wratten #25 filter, taken on July 20, 1994)

SPOTS K/W, L, G/D, S, R, AND Q_1 SPECKLE JUPITER'S FACE
by Harry Roberts

(8-inch SCT at f/250, Kodak Gold 200 film, 3-second exposure taken on July 28, 1994)



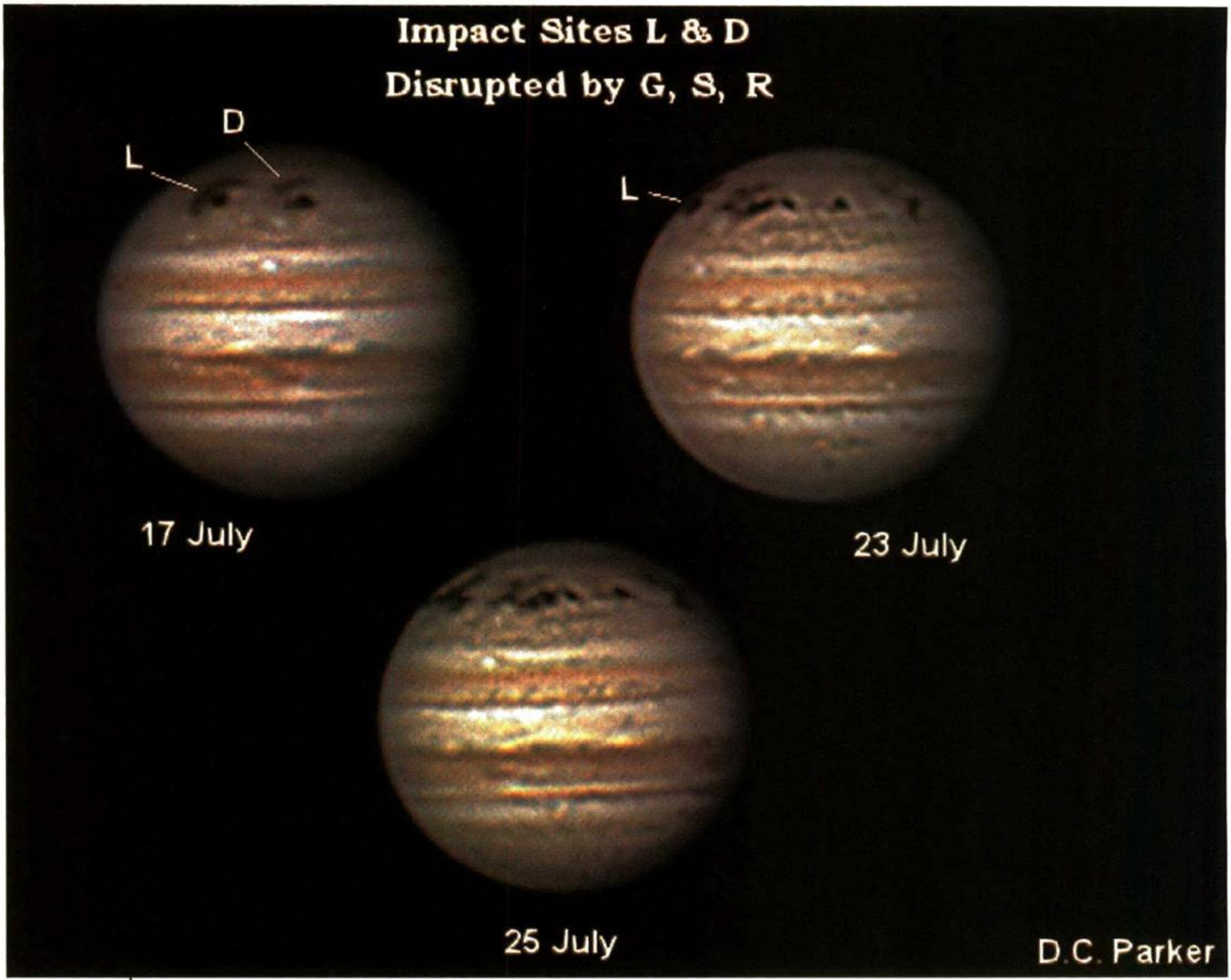


A SPOTTY LINEUP: L, G/D, S, R, AND Q_1
by Donald G. Bruns

(10-inch SCT, Fuji Velvia 50 film, 28-second exposure, taken on July 22, 1994)

was incredible — here was an event of historic proportions that failed to fizzle.

On July 19 Ralph E. Mackenstein of Seymour, Connecticut, found the spots easily visible in a 60mm refractor at 72x. "The only Jovian features I could see were the two belts, the northern one being darker, and the black spots that resulted from the collisions. In fact two spots located near each other were the most conspicuous features on the planet."

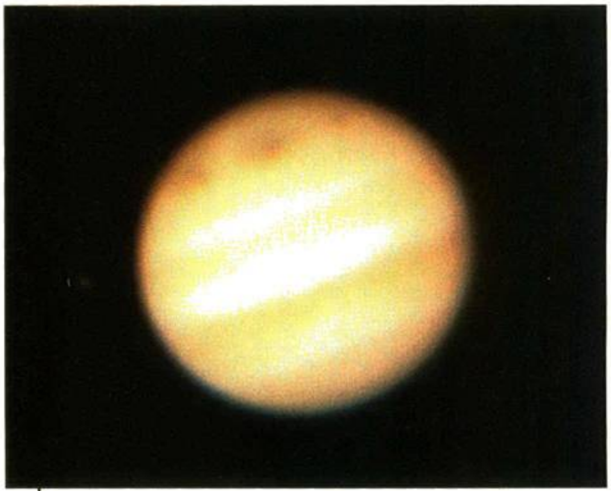

Impact Sites L & D
Disrupted by G, S, R
D
L
L
17 July
23 July
25 July
D.C. Parker

Crash Sites L and D Are Disrupted
by Donald C. Parker

(16-inch f/7 reflector, Lynxx CCD camera, images taken on July 17, 23, and 25, 1994)

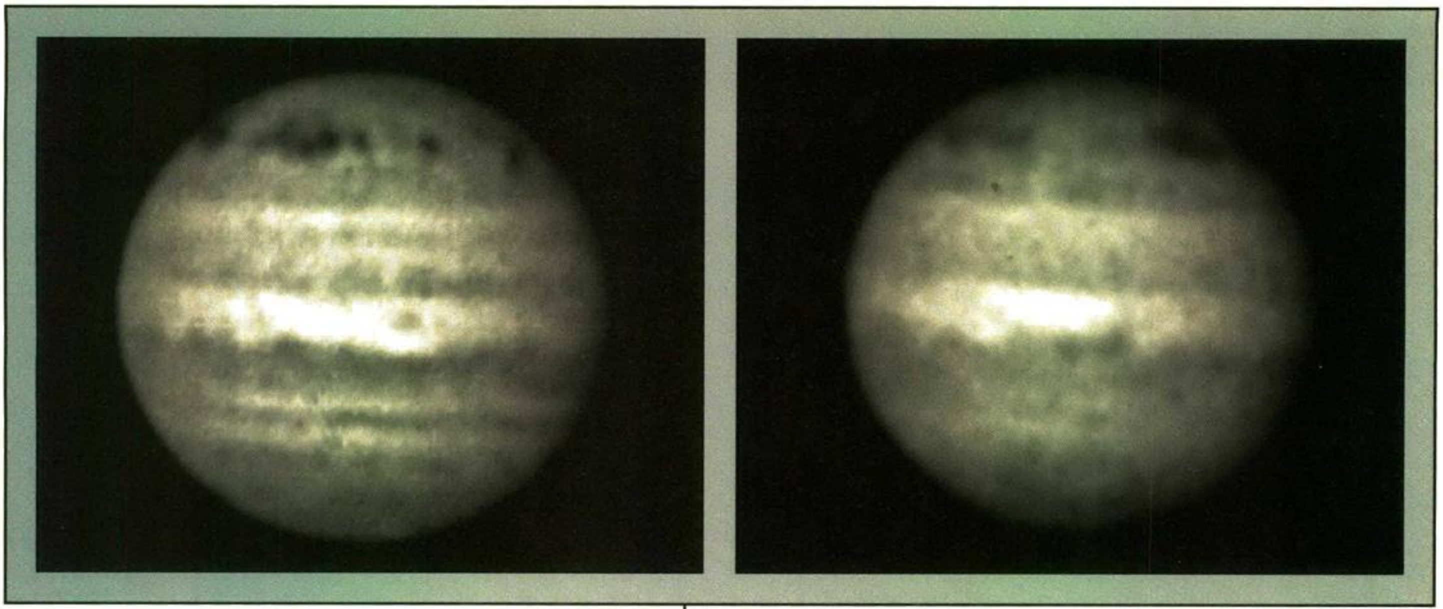
Two Weeks After Impact A (L to R: sites K, W, and L)
by Mark Schmidt

(14-inch SCT at f/95, ISO 100 film, 4-second exposure taken at 10:17 p.m. EDT on July 29, 1994)



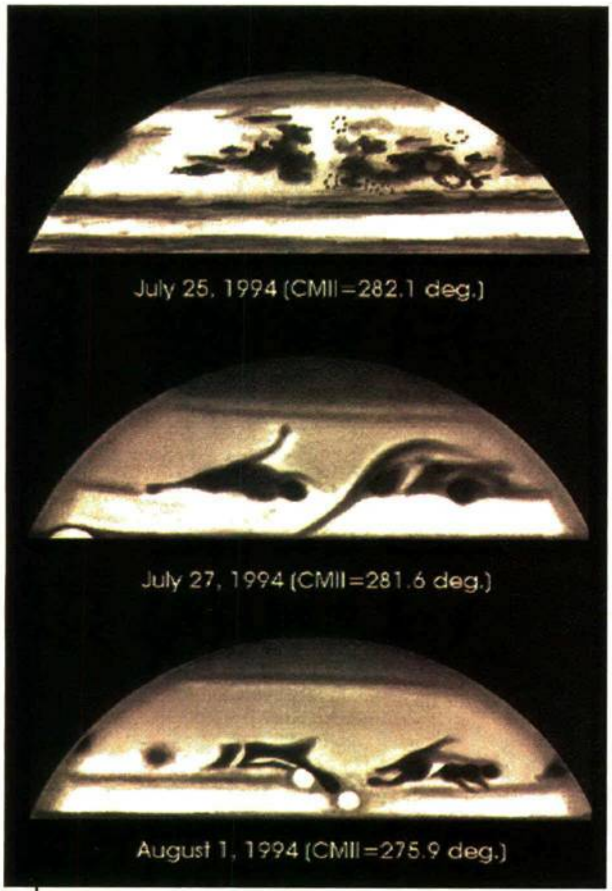
Jupiter's Embattled Cloudtops (L to R: sites L, G/D, S, and H)
by Jonathan Dietch

(8-inch reflector at f/275, Kodak Royal Gold 1000 film, 1-second exposure taken at 11:55 p.m. EDT on July 21, 1994)



ONE WEEK AFTER THE STRIKES
(L TO R, LEFT IMAGE: SITES L, G/D, S, R, Q_1, AND H; RIGHT IMAGE: SITES K/W, L, S, AND G)
by David Hanon

(7-inch refractor at f/56, ST-4 CCD camera, taken at 9:50 p.m. EDT on July 24, 1994, left, and 10:32 p.m. EDT on July 28, 1994, right)



July 25, 1994 (CMII=282.1 deg.)

July 27, 1994 (CMII=281.6 deg.)

August 1, 1994 (CMII=275.9 deg.)

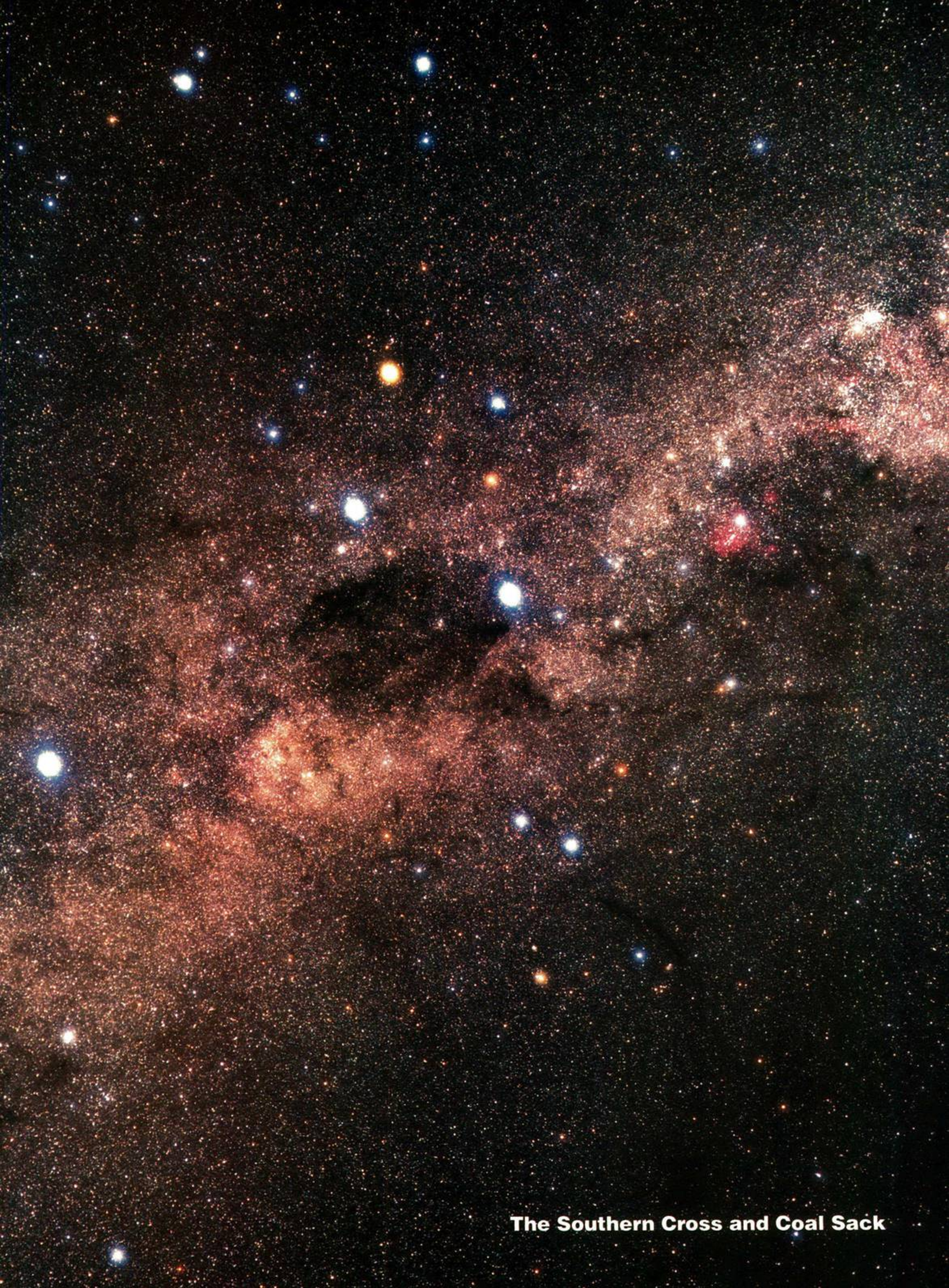
DISTURBANCES LINGER IN JUPITER'S CLOUDTOPS
Sketches by Jeffrey D. Beish and Carlos E. Hernandez

(Top: Jeffrey D. Beish, 16-inch f/7 reflector at 382x and 585x sketched at 8:22 p.m. EDT on July 24, 1994; center: Carlos E. Hernandez, 16-inch f/7 reflector at 382x sketched at 10:00 p.m. EDT on July 26, 1994; bottom: Carlos E. Hernandez, 16-inch f/7 reflector at 382x sketched at 9:00 p.m. EDT on July 31, 1994)

"What a surprise it was to see that first inky black spot," says Charles Manion of Owensboro, Kentucky. "On July 18, from 9 to 11 p.m. CDT, I continued to watch it slowly move across the face of Jupiter. It was an incredible sight." Robert Royce of Northford, Connecticut, sketched the planet with a 10-inch f/25 Gregorian reflector. "I was amazed to see two of the spots, U and G, displaying a significant smearing. The spots spread out into pancake-shaped areas by July 21," he says.

Jeff Jones of Hewitt, Texas, observed the planet for three nights before spotting a crash site. "In my 60mm refractor I was able to see two spots on July 19," he says. "They appeared as red-brown holes in the planet's glowing clouds, and I later discovered they were impact sites G and L." Despite high clouds that played tag with Jupiter, Eric Gawain of St. Thomas, U.S. Virgin Islands, observed the spots from his beachfront condo using a 6-inch reflector. "The spots were incredibly black," he says, "like the shadows from a Jovian moon transiting the planet's cloudtops."

And the Jupiter watch goes on. In mid-August many of the spots remained prominently visible, and astronomers expected them to remain so for weeks or months to come. While they are continuing to watch the zones of destruction, backyard astronomers are already filing their fond memories of the central week of the event. Says Randy Pakan, an observer in Edmonton, Alberta, "This event has done more for us than a dozen Halley's Comets!" What great, unexpected event lurks out in the distant solar system now? A bright comet? A Leonid meteor storm? We can only wait and watch and hope, content for having seen this rare and spectacular death of a wayward comet. ☐



The Southern Cross and Coal Sack

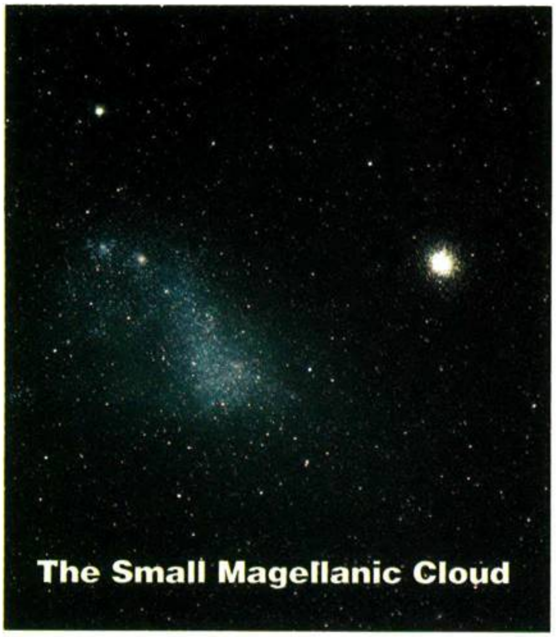
Under The Southern Sky

PART II

An Australian astrophotographer presents the Galaxy from Down Under.

Story and photos by Luke Dodd

"The southern sky has all the good stuff," astronomer Bart Bok used to say, referring to the many bright clusters and nebulae visible only from the Southern Hemisphere. (See "Under the Southern Sky" by Jim Barclay, October 1994). He was exaggerating, of course, for the sake of ruffling Yanks. But his braggadocio raised enough eyebrows in the North to focus some long deserved attention on southern vistas such as the Coal Sack, the Magellanic Clouds, the Southern Cross, and constellations like Carina, Centaurus, Scorpius, and Sagittarius. (Yes, the last two are southern constellations.)

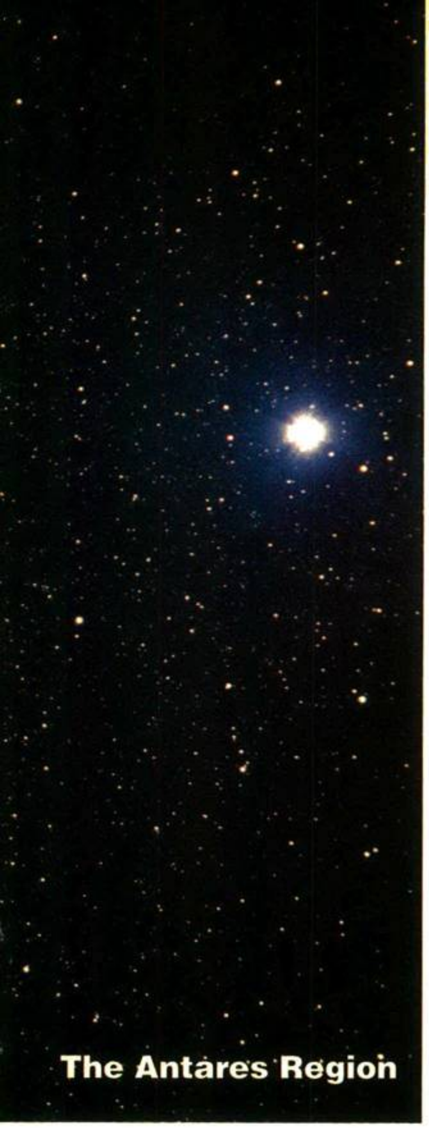

The Small Magellanic Cloud

Such panoramic swaths of rich Milky Way beg for crisp, wide-field photography, in color of course. As a dentist in the Royal Australian Army based in Brisbane, I don't have as much time as I would like to pursue astrophotography. But the time I do have goes toward imaging the South's finest objects using telephoto lenses of 105mm and 300mm focal length (for capturing entire constellations or rich regions of nebulosity) and a 4.7-inch f/8.5 apochromatic refractor, which produces sharp closeups of deep-sky objects. I nearly always use hypersensitized Fujicolor 400 film, and I typically expose for periods of 45 to 90 minutes. To increase the contrast and color saturation of an image, I'll often create a print by sandwiching two negatives. These techniques capture the drama of the many wonders of the southern Milky Way.

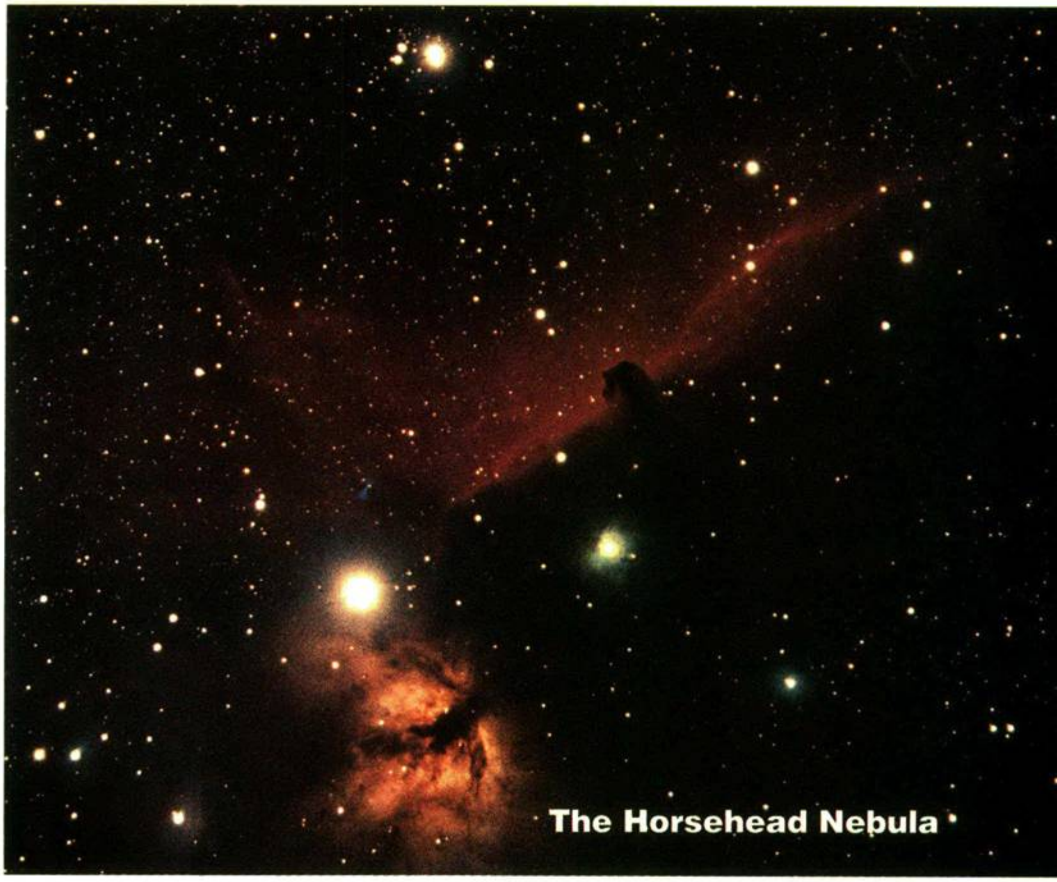
Because of the rich fabric of nebulae and star clusters in the region, no part of the sky better illustrates the success of these techniques than that surrounding the Southern Cross. I recently captured this region (opposite page) with a 105mm lens at f/3. The print, an integration of two 20-minute exposures, shows the Southern Cross (top), the dark nebula known as the Coal Sack (center), the bright stars Alpha and Beta Centauri (lower left), and the Jewel Box Cluster (south of the star Beta Crucis, near the center of the image). All of this detail plays against a curtain of bright and dark nebulosity and the light from countless unresolved stars in the Orion arm of the Galaxy.

Such a combination of telescope, film, and technique can also look outside the Galaxy to our nearest neighbors, the Magellanic Clouds. I captured the Small

The Lambda Centauri Nebula



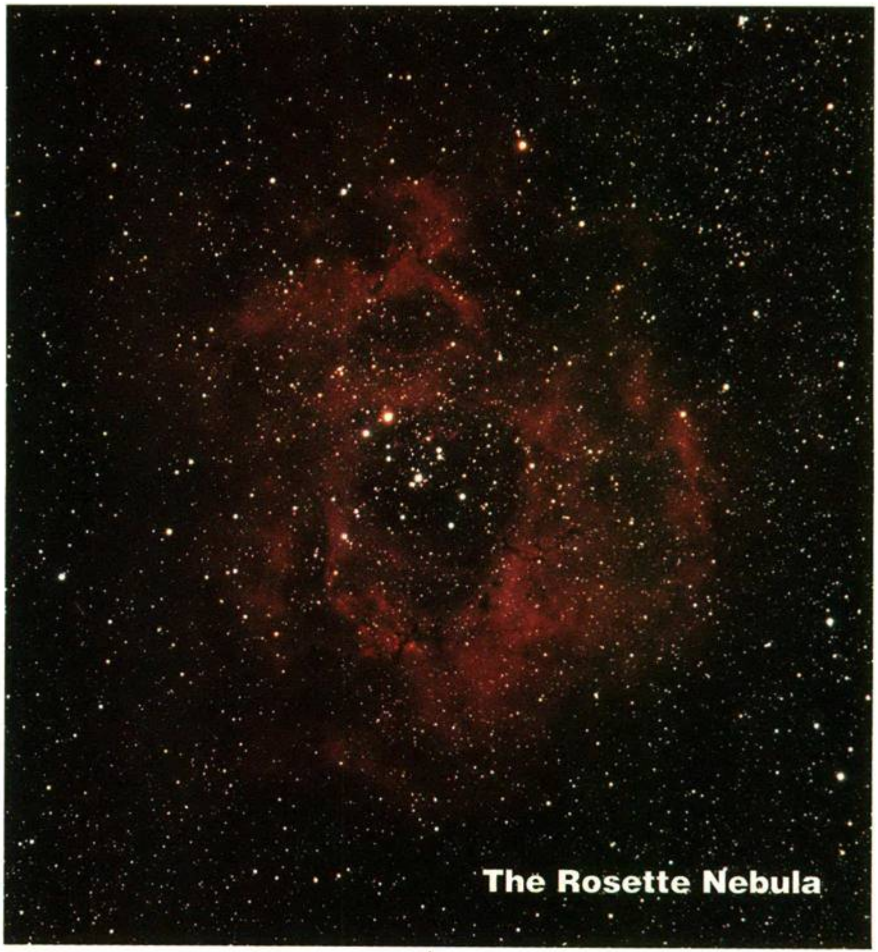
The Antares Region



The Horsehead Nebula

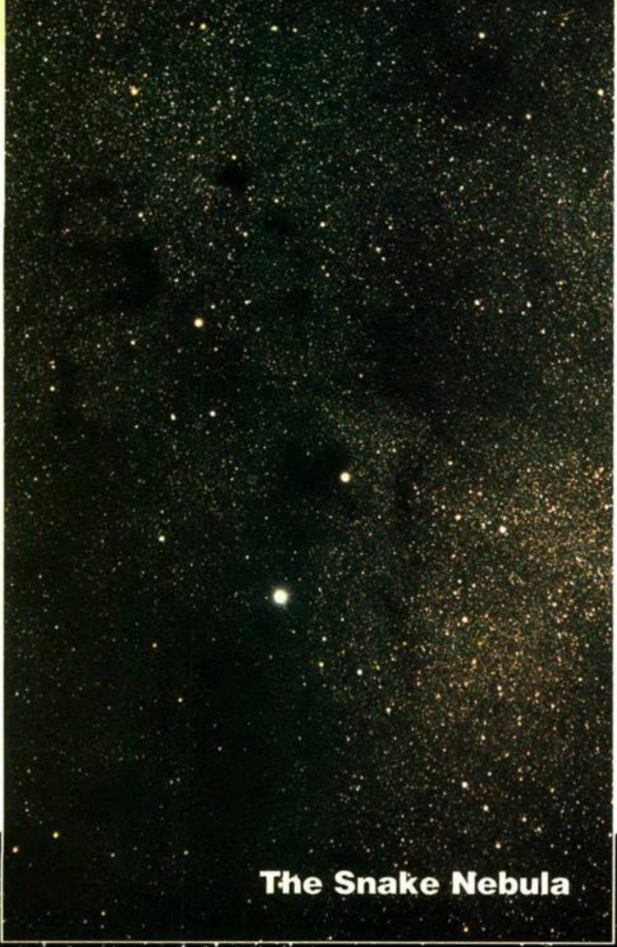
Magellanic Cloud (page 67) using a 300mm lens at f/4. The object is so large it appears as a pear-shaped glow to the naked eye and offers a sparkly field of light in a wide-field scope. The bright globular cluster 47 Tucanae, a member of the Milky Way, floats to the right side of the galaxy. Other crisply rendered, colorful globular clusters and fields of nebulae lie closer to home, as with M4 and the bright star Antares (above), which when photographed with the same technique are surrounded by blue and red sheets of nebulosity. The refractor provides the image scale to capture a picture of the area, revealing the nebulae and resolving the outlying stars of M4.

The refractor also works well for showing a multitude of medium-sized clusters and nebulae because of its relatively wide field and sharp images. Take, for example, the ruddy

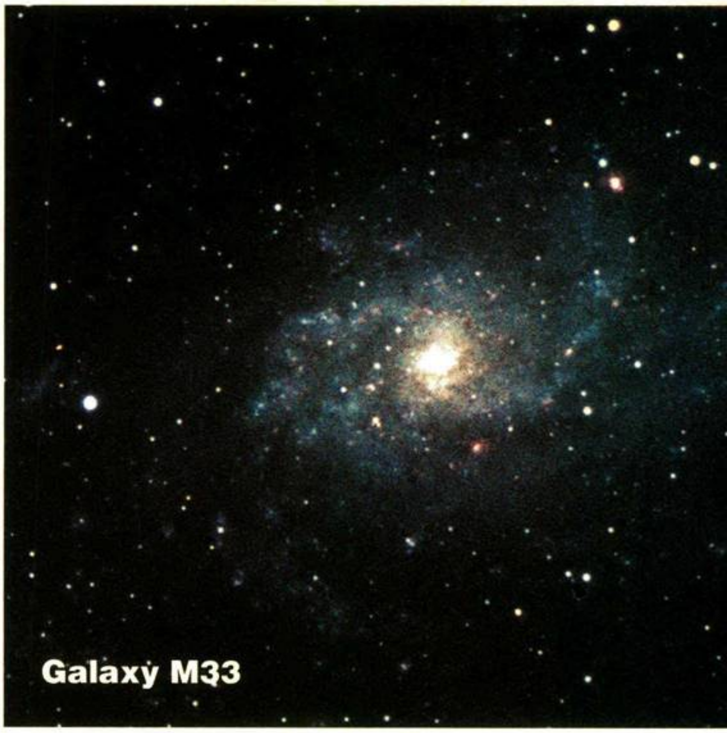


The Rosette Nebula

Scorpius



The Snake Nebula



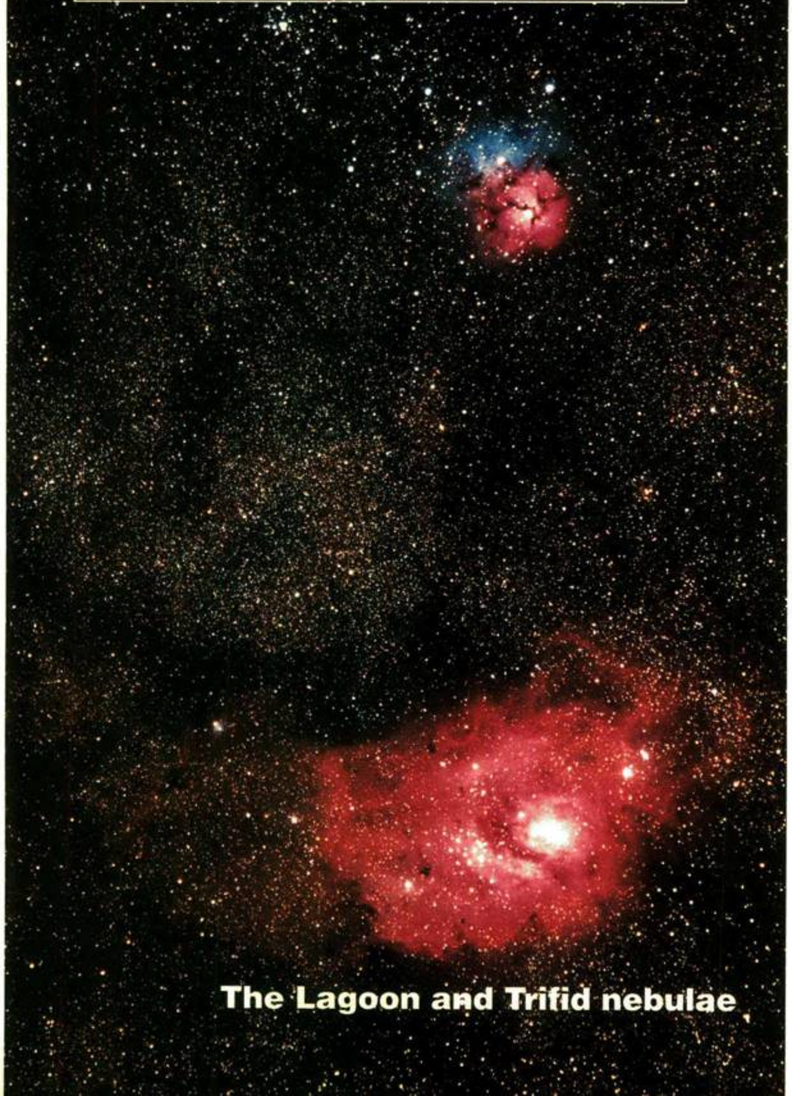
Galaxy M33

glow surrounding the star Lambda Centauri (page 68). This is IC 2944, an emission nebula spanning 75' by 50' (an area four times as large as the Full Moon) and powered by the intense radiation of 3rd-magnitude Lambda. The combination of the refractor's sharpness and the color film nicely captures the Horsehead Nebula in Orion (page 69) and the Rosette Nebula in Monoceros (page 69).

The constellation Scorpius (opposite page), a star group I photographed with a 105mm lens at f/3 and a 20-minute exposure, passes nearly overhead from Brisbane. The resulting image shows dozens of clusters and nebulae, from the Antares region (upper right) to the rich Table of Scorpius (below center) and the "stinger," with the brilliant clusters M6 and M7 (lower left).

Dark nebulae offer a challenge to astrophotographers as well as visual observers, but outstanding examples like the Snake Nebula in Ophichus (above, left) can be captured with the refractor. The dark features that cross the faces of nebulae like the Lagoon and Trifid in Sagittarius (left) are far easier to record using my setup, as are examples of more distant game like the spiral galaxy M33 in Triangulum (above), an object that observers in both hemispheres can see with telescopes, eyes, and film. Perhaps the southern sky doesn't hold all the good stuff after all! □

Luke Dodd is an enthusiastic astroimager living in Brisbane, Australia. He has contributed numerous photos and drawings of deep-sky objects to ASTRONOMY.

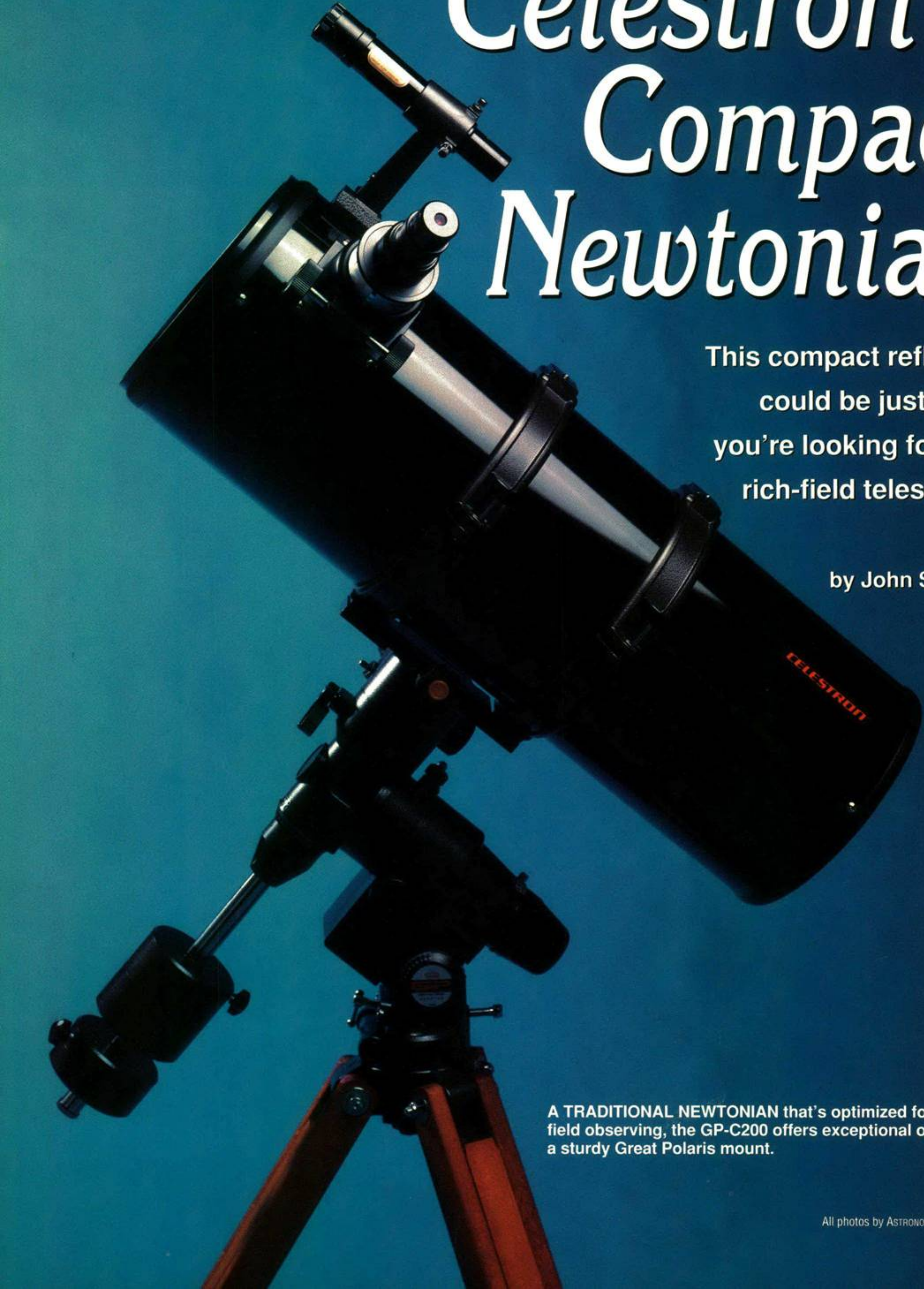


The Lagoon and Trifid nebulae

Celestron's Compact Newtonian

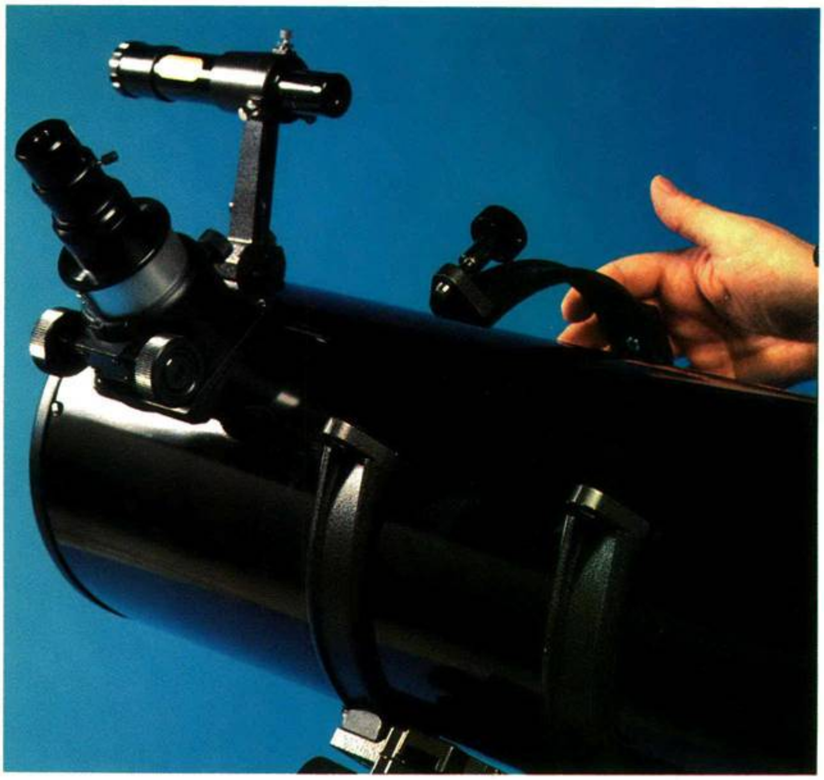
This compact reflector could be just what you're looking for in a rich-field telescope.

by John Shibley



A TRADITIONAL NEWTONIAN that's optimized for rich-field observing, the GP-C200 offers exceptional optics on a sturdy Great Polaris mount.

All photos by ASTRONOMY: Jim Forbes



ALUMINUM TUBE RINGS lined with felt let the tube rotate freely when retaining knobs are loosened. The knobs can be easily loosened or tightened with a gloved hand, a useful feature when observing in cold weather.

Nothing beats an evening prowling the summer Milky Way with a rich-field telescope. Into one amazing field of view you can crowd all of the North America Nebula or the whole Scutum star cloud, with M11 tucked into one corner. Then there's that dark nebula between Cygnus and Cepheus . . . again in one field of view.

Celestron's new 7.9-inch f/4 Newtonian telescope is designed for those who enjoy scanning the heavens at low power with a moderate aperture. Some call this observational approach the "travel light but carry a big scope" way of doing amateur astronomy. And in a time when an observer needs to travel miles to escape light pollution, scope portability takes on a whole new meaning. A traveler's dream, the GP-C200's 800mm focal length fits into a tube less than three feet long and 8½ inches in diameter, and weighs less than 15 pounds. When racked in all the way, the two-inch focuser sticks out only four inches from the tube assembly. And the finderscope releases from a dovetail bracket for storage.

Equally portable is the Great Polaris equatorial mount (made for Celestron by Vixen), which the optical tube assembly connects to by means of a quick-release dovetail bracket. The mount has extendable wooden legs topped by an ample equatorial head. Built into the tripod leg spreaders are holes for mounting an accessory tray that comes with the scope. Together, the tripod and equatorial head weigh 28 pounds; a good deal of that comes from two removable 6-pound counterweights that balance the optical tube.

TOSS IT ON THE BACKSEAT, or carry it under an arm. At 13 pounds and 28 inches long, the GP-C200 is lightweight and short.

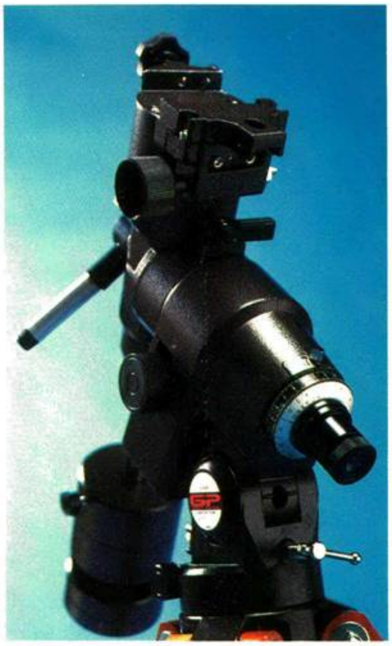
Great Optics

At the heart of the GP-C200 is a fully aluminized 7.9-inch Pyrex primary mirror with enhanced coatings to improve reflectivity. The mirror is supported in its cell at three points and held in place with three edge clips. You collimate the primary mirror by using a hex wrench to adjust three sets of push/pull button-head screws that lie flush with the sealed end of the telescope tube. Three hex-head screws that are covered by a removable metal plate adjust the secondary.

Celestron mentions in the telescope's manual that the optics leave the plant in perfect collimation and suggests you may never have to perform any adjustments on the mirror. Treating this with a modicum of skepticism, I carried the scope out to a backyard site several times and threw it on the back seat of my car for two trips to a dark-sky site. After being subjected to several weeks of rigorous handling, the optics stayed in collimation. Obviously, what appears to be a simple mirror cell works more than adequately in keeping the main optics aligned.

But fine collimation amounts to nothing if the main mirror is fabricated imperfectly. In star tests using a 7mm Nagler eyepiece coupled to a 2.5x TeleVue Barlow (230x), the mirror displayed virtually identical diffraction rings on either side of focus. If the main optics had spherical aberration, the inner diffraction rings would have looked brighter inside of focus and dimmer outside of focus. The perfectly circular ring pattern also attested to the system's precise collimation and the lack of any astigmatism. Also, if the main mirror were in any way pinched by its mounting cell; the circular ring pattern would have appeared deformed.

My evaluations coincided with the



BUILT INTO THE POLAR AXIS is a finderscope to locate the north celestial pole. Calibration dials at the eyepiece's base adjust for local time and season. An illuminator (silver tube protruding from the left side) lights the finder's polar-locating reticle.

impact of Comet Shoemaker-Levy 9 on Jupiter. Under the scrutiny of 230x, the planet's belts, zones, ovals, and festoons appeared distinct, as did the numerous comet impact sites. This level of planetary image fidelity impressed me, considering that the GP-C200 is an f/4 system better suited to wide-field observing. The secondary mirror blocks a substantial portion of incoming light; its area is 28 percent that of the primary mirror. Despite this, images through the eyepiece still showed a remarkable level of contrast.

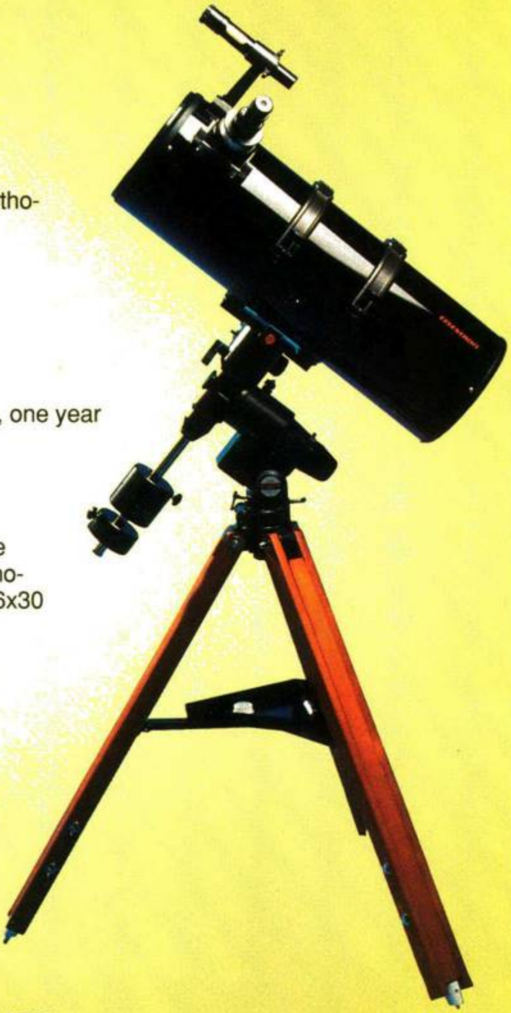
So you can obtain a greater range of magnification from your collection of eyepieces and have more flexibility for photography, Celestron offers a tele-extender that increases the GP-C200's focal length to 1,440 mm and its focal ratio to f/7.5. This accessory threads into the focuser assembly and yields more observing flexibility when you need higher powers. I used this accessory and a 7mm Nagler (212x) to split clearly Lyra's famous "double double," Epsilon (ε) Lyrae. I was quite satisfied with the results.

But the GP-C200 really shines in the area of rich-field observing. For this I used a University Optics 20mm Wide Scan eyepiece, which yielded a view of just over 2° at a magnification of 40. As was to be expected with a low f/ratio scope like the GP-C200, stars on the eyepiece's edge of view had the appearance of being slightly flattened, an effect called "coma."

CELESTRON GP-C200

STANDARD SPECIFICATIONS

Aperture:	7.9 inches (198 mm)
Focal ratio:	f/4
Focal length:	800 mm
Length of tube:	28 inches
Size of focuser:	2 inches
Eyepiece:	12.5 mm (1.25-inch Orthoscopic 64x)
Photographic field:	1.7° x 2.8°
Weight of tube assembly:	13 lbs.
Weight of Tube and GP mount:	41 lbs.
Height to bottom of equatorial head	
Tripod legs extended:	45 inches
Tripod legs retracted:	29 inches
Warranty:	limited lifetime (optics), one year on everything else
Suggested list price:	$2,590
Typical retail price:	$1,549 (Includes accessory tray, tube cap, 1¼-inch eyepiece adapter, 12.5 mm Orthoscopic eyepiece, and 6x30 finder.)



OPTIONAL ACCESSORIES

(Suggested list prices; actual prices vary with dealer)

Great Polaris motor and drive controller:	$450
Motor drive installation kit:	$398
2-inch eyepiece adapter:	$60
4-element coma corrector:	$330
2-element coma corrector:	$190
f/7.5 tele-extender:	$130

Also available: Advanced Astro Master digital setting circles, photographic tele-extender tube, T-adapter, GP half pier, and vibration suppression pads.

Celestron, 2835 Columbia Street, Torrance, CA 90503, (310) 328-9560

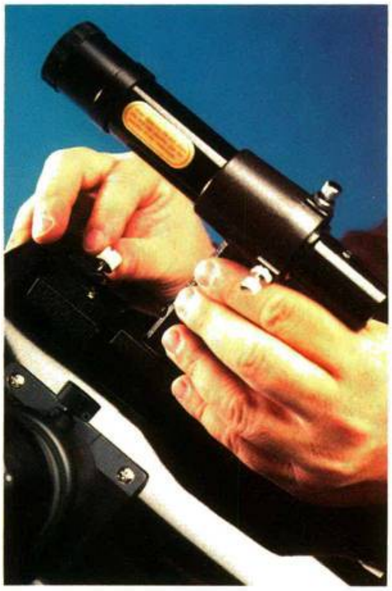
After threading Celestron's optional coma corrector into the focuser, I was rewarded with edge-to-edge sharpness with no apparent loss of brightness or contrast. I spent hours wandering the length of the summer Milky Way and greeted the dawn by looking at M31 and many open clusters sprinkled throughout Cassiopeia and Perseus.

The Tube

These optics are housed in a rolled aluminum tube finished with high-gloss, chip-resistant black paint. Complementing the scope's potential is a 2-inch focuser that racks in and out through a distance of one inch. Threaded surfaces and adapter rings incorporated into the focuser barrel allow for the attachment of Celestron accessories such as a coma corrector, an f/7.5 tele-extender, an off-axis guider, a 2-inch eyepiece adaptor, or a 1¼-inch eyepiece adapter (which comes with the scope). Oversized, 1¼-inch knobs make the rack-and-pinion focuser easy to operate. A lock knob holds the barrel in place once you reach the desired focus.

The GP-C200 comes equipped with a 6x30 finder that slips and locks into a dovetail track just forward of the focuser. The finder stands 4½ inches off the tube, which makes it very easy to sight objects without bumping the main scope. The tube's dovetail track is universal enough to accept holders that accommodate larger finders from Celestron or other suppliers.

Tube rings secure the telescope to the rest of the mount. The tube can be rotated to a convenient viewing angle by loosening the 1¼-inch knobs, which are large enough to grasp with gloves — a bonus for wintertime observers. Inside each ring is a layer of felt that allows the tube to rotate smoothly and stay firmly in place after the ring knobs are tightened. Protruding through the top of each ring is the threaded end of a hex-socket screw. These serve as attachment points for guidescope brackets or a piggy-back camera platform.



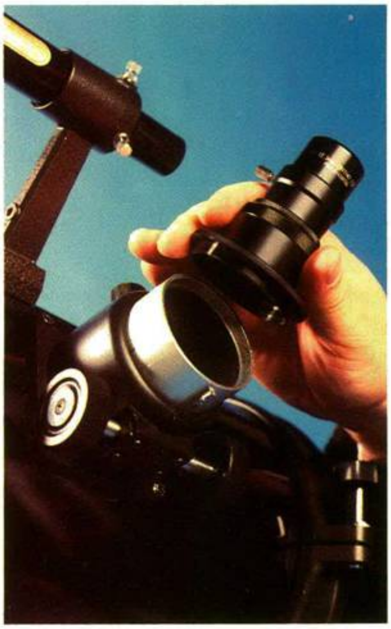
AN EXTRA-TALL FINDER MOUNT means you won't bump the telescope tube when finding objects. The finder also detaches for easy storage.

The Mount and Tripod

Before attaching the telescope to the equatorial mount, it's important to align the mount with the north celestial pole. First the mount's polar axis must be set at the same angle as the observer's latitude. This is very easy using a fine altitude adjustment screw along with the latitude scale printed near the pivot point of the axis. The GP mount can be adjusted to work between latitudes 15° and 65°.

Once the polar axis is set to the proper angle, it must be aimed at the north celestial pole. For general observing, precise alignment isn't really necessary; the polar axis need only point in a northerly direction. A raised letter "N" on the GP mount indicates which side should face north. This rough alignment method provided me with enough precision to keep an object centered in a medium-power eyepiece using the mount's hand-operated, slow-motion controls.

For astrophotographers who require a more precise alignment, the GP mount's polar axis has a north celestial pole finderscope built into it. The finderscope reticle has illuminated crosshairs that pinpoint the pole's location, and two adjustable scales take into account the time of year and local time. For further alignment, a fine adjustment knob pivots the equatorial head left and right. A five-minute procedure using these features aligns the mount dead on the pole. For doing astrophotography, this eliminates a major source of tracking error. The GP-C200 also has clear instructions on how to precision-align in the Southern Hemisphere, where no bright pole star like Polaris exists.



VISUAL AND PHOTOGRAPHIC accessories thread into the focuser barrel. Options include a coma corrector, f/7.5 tele-extender, T-adapter, and adapters for 1¼- and 2-inch eyepieces

A steady mount is critical for both photographic and visual use. While observing at around 200-power, I rapped the mount and measured an exceptional dampening time of between 2 and 3 seconds. This time remained consistent through a wide range of light-weight to heavy eyepieces.

Not only is the mount stable, but it has a very smooth manual tracking system. Keeping an object centered, even at high power, was simple using 1½-inch-wide slow-motion knobs attached to the right ascension and declination axes. Astrophotographers should be aware that a drive controller, which includes motors for both axes and a control paddle, is available from Celestron at extra charge. While not having a drive motor at first seemed to be a hindrance to observing, I found that the mount's slow-motion controls were more than adequate for rich-field, low-power observing. And it's this level of observing that the scope excels at.

In all I found the GP-C200 to be a stellar performer, both mechanically and optically. And for a few dollars more, the telescope should prove itself to be an exceptional astrophotographic tool. Is it worth the $1,500 price tag? For a portable, photographically fast telescope I believe it is. The GP-C200 design offers the astrophotographer and visual observer plenty of room to roam through their respective areas of interest. In this era of optimized refractors and hybrid reflectors, it's especially refreshing to see that the time honored, rich-field Newtonian reflector hasn't been neglected by commercial telescope manufacturers. ☐

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O. Richard Norton
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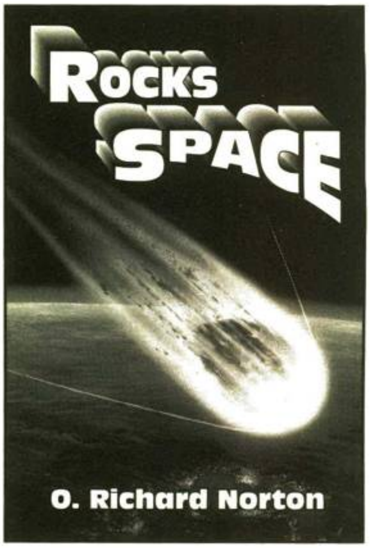

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READER REPORTS

Perseids '94: Bright Delight But No Storm

For the second year in a row the storm didn't show. Before this year's Perseid meteor shower, which peaked during the second week of August, some astronomers believed an anomalously high number of meteors might fill the sky during the early mornings of August 11, 12, and 13. The prediction was based on the return of Comet Swift-Tuttle in 1992, which might have left a denser than normal cloud of debris to encounter Earth this year. If Earth passed through this dense pocket of material, then observers could see huge numbers of meteors.

But although no bonafide storm took place, the 1994 Perseid shower was one of the best in recent years. The absence of the Moon from the early morning sky enabled those with clear weather to view large numbers of relatively bright Perseids. Peter Brown of the University of Western Ontario reported that several observers of the International Meteor Organization recorded a steadily rising number of Perseids from 5:20 a.m. to 7 a.m. EDT on August 12. Observing from the California-Nevada border, they witnessed a peak zenithal hourly rate of 250-300 Perseids near 7:00 a.m. After this hour the rate fell dramatically.

Other western observers noted brisk activity. Viewing from outside Boise, Idaho, Mike Fraley and Chris Curtis monitored the sky for nearly seven hours, from 2 a.m. to 8:45 a.m. EDT on the 12th. They were astonished by the high activity and claim to have spotted between them 629 Perseids, the greatest concentration occurring between 6 a.m. and 8:30 a.m. EDT. "During this time we observed more than 350 Perseids," says Fraley. "That's nearly $2^{1}/_{2}$ meteors per minute!" Others weren't so overawed, however. Farrin Rosenthal of Los Angeles traveled to the mountains north of Santa Barbara and saw on average one meteor every four minutes. "One meteor made the trip," says Rosenthal. "A magnitude –2 or brighter fireball streaked across the entire sky early in the evening; it was beautiful." Another westerner, Ken Hewitt-White, watched the show from Mt. Kobau, British Columbia. "There were many instances of meteors arriving in bunches followed by periods of relative inactivity," he says.

Further east, meteor watcher George Gliba began observing the shower on August 5/6, from the Stellafane convention in Springfield, Vermont. From 2 a.m. to 4 a.m. EDT he logged 71 meteors, 27 of which were Perseids. "The prettiest one was a magnitude –3 bluish meteor that left a train visible to the naked eye for 10 seconds," he says. On August 12, Gliba observed from Mathias, West Virginia, and under a mostly clear sky spotted 18 Perseids beginning at 12:51 a.m. EDT. Florida observers Gregory Zentz and Timothy Printy reported a high number of bolides. "We saw two bright bolides within a minute of each other, including a magnitude –10 object that left a train visible for two minutes," says Zentz, who watched along with members of the Northeast Florida Astronomical Society from the Osceola National Forest west of Jacksonville.

Over the course of seven nights, James N. Smith of Glenwood, New Brunswick, reported 379 Perseids and a lower number of bolides leaving trains than he normally sees. "The weather here was a meteor observer's dream," he reports. "Six clear nights and no storm but among the best Perseid showers in terms of numbers I've seen, equalled perhaps by some showers in the early 1970s." Much further east, in Szomolya, Hungary, Istvan Tepliczky and other members of the Hungarian Astronomical Association recorded between 300 and 400 meteors during six hours on August 12/13. ☐

ASTRONOMY wants to hear about your observations of the sky. Send reports, sketches, and photographs to David J. Eicher, Reader Reports editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187. Please label each photo with name, address, and social security number. You may send written reports via the Internet to 72000.2704@CompuServe.com

A Perseid Flashes Through Cygnus

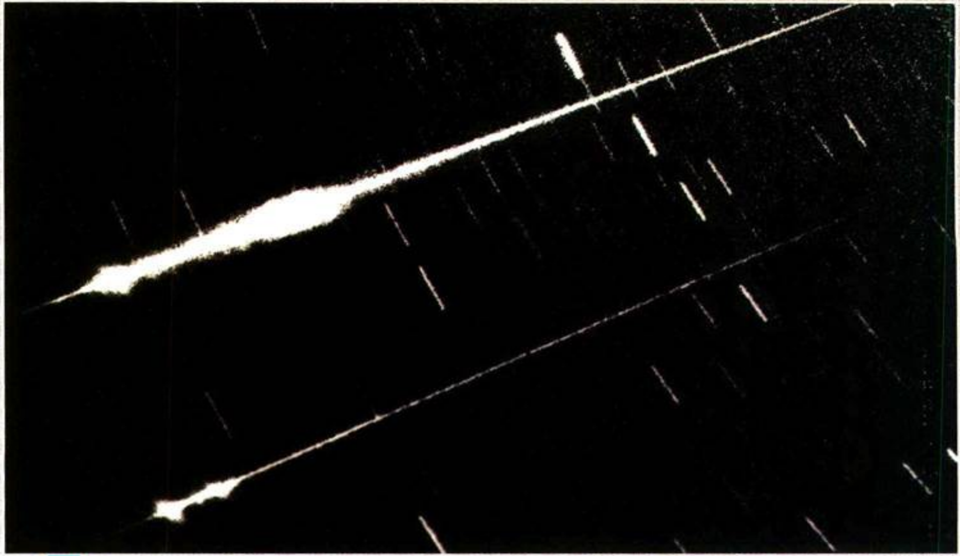
by Keith A. Corban (28mm lens at f/3.5, Kodak Ektar 1600 film, 20-minute exposure taken on August 12, 1994)

An Exploding Perseid Fireball

by Dan Smiley (24mm lens, Fuji Super HG 400 film, taken on August 12, 1994)

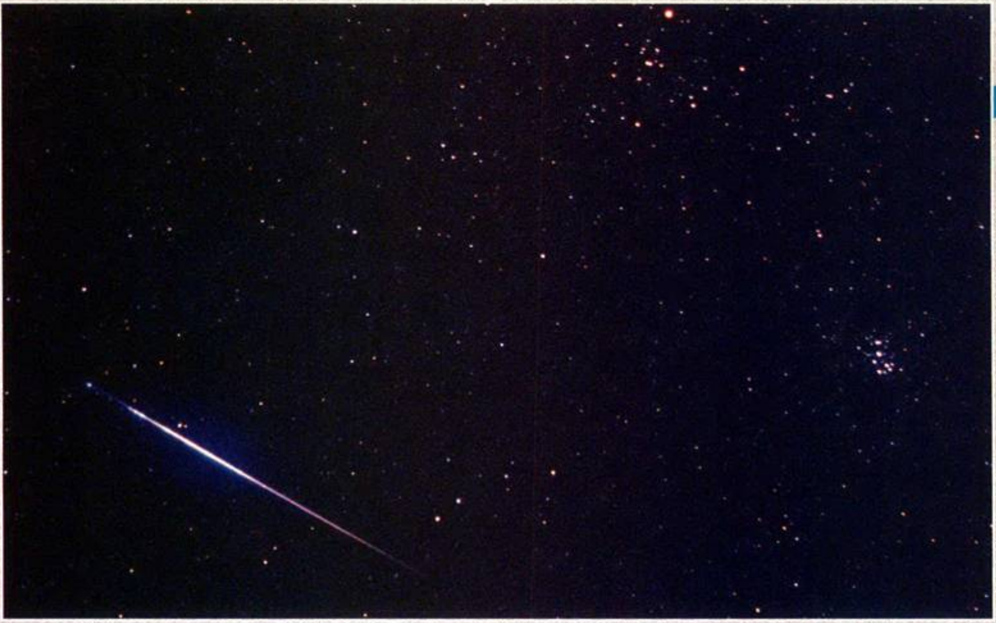
A BOLT IN THE LONG NIGHT

On the night of maximum activity for this year's Perseid meteor shower, Vic Winter and fellow members of the Kansas City Astronomical Society traveled to Colorado's Rocky Mountain National Park to observe. Early in the morning of August 12, Winter captured this portrait of a magnitude –6 Perseid fireball as it lit up the sky (opposite page). The image wins this month's $100 Best Astrophoto award.



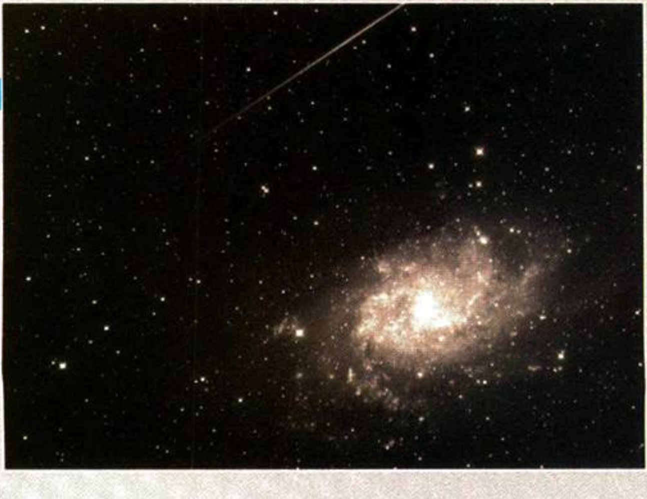
Twin Streaks Cross Draco

by Len Nelson
(28mm lens at f/2.8, T-MAX 3200 film, taken on August 12, 1994)



A Perseid, the Hyades, and the Pleiades Triangulate

by Andy Druga
(50mm lens at f/1.7, Fuji Super HG 400 film, 5-minute exposure taken on August 12, 1994)

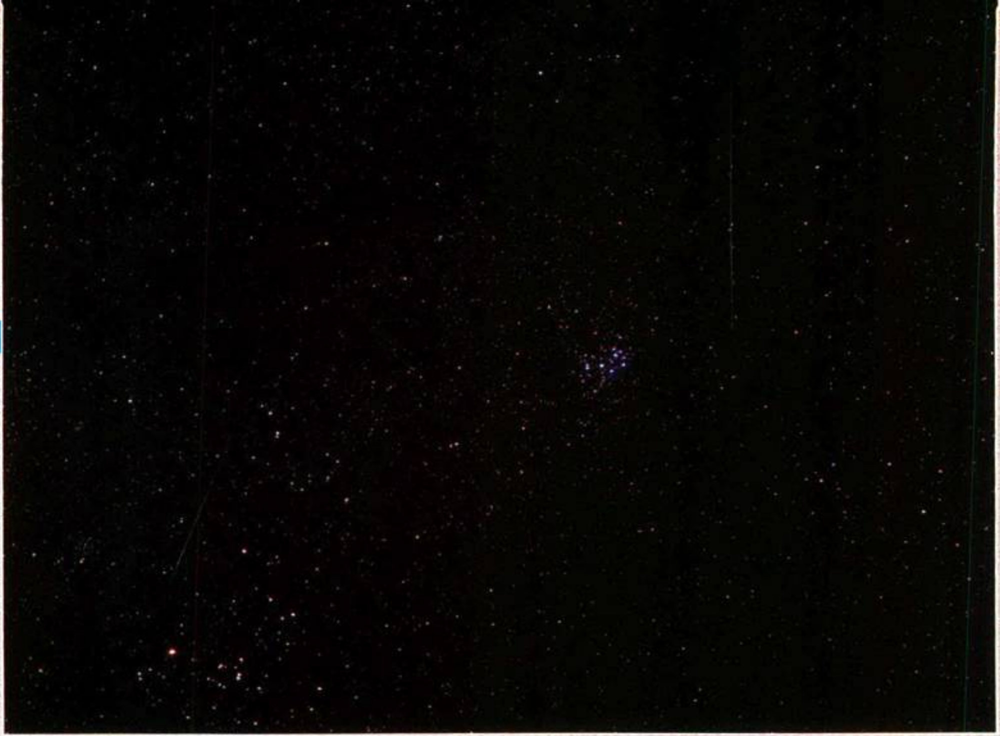


A Perseid Grazes Galaxy M33

by Chuck Vaughn
(7.9-inch f/4 hyperbolic astrograph, hypersensitized Tech Pan film, 45-minute exposure taken on August 4, 1994)

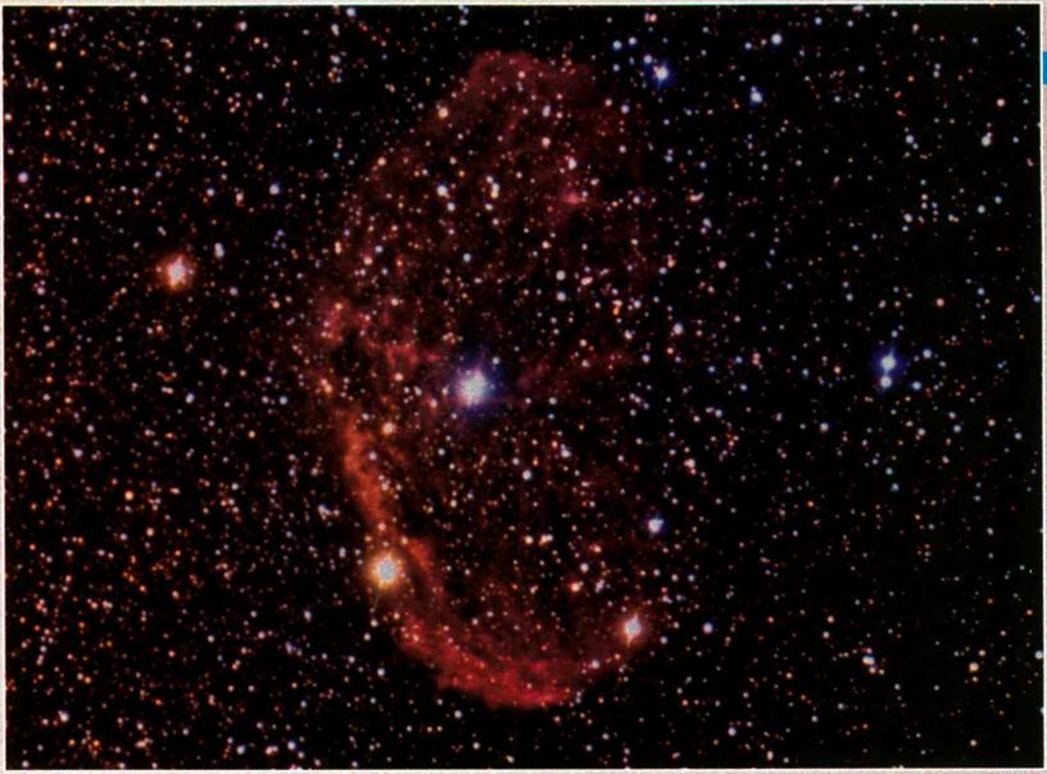
A Perseid Fireball over Colorado

by Vic Winter
(8mm lens at f/2.8, Kodak Ektapress 1600 film, 20-minute exposure taken on August 12, 1994)



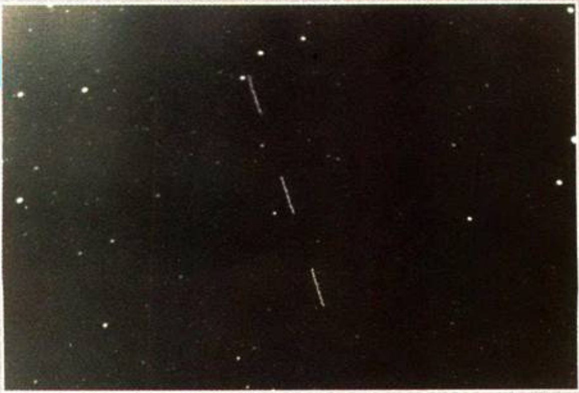
Perseids Meet Pleiades and Hyades

by John A. Volk
(105mm lens at f/4, Fuji Super HG 400 film, 40-minute exposure taken on August 12, 1994)



The Crescent Nebula (NGC 6888)

by Bill and Sally Fletcher
(16-inch f/4.5 reflector, hypersensitized Tech Pan film, tricolor composite using 65-minute red, 90-minute green, and 125-minute blue exposures)



Asteroid Geographos Speeds Past Earth

by Frank J. Melillo
(8-inch f/10 SCT, hypersensitized Tech Pan film, 30-minute exposure showing 10-minute intervals of motion separated by 15-minute gaps, taken on August 30, 1994)

Circumpolar Star Trails over Rob's Tree

by Mark E. Seibold
(28mm lens at f/2.8, Kodak Royal Gold film, 45-minute exposure with a handheld flash to illuminate the tree)

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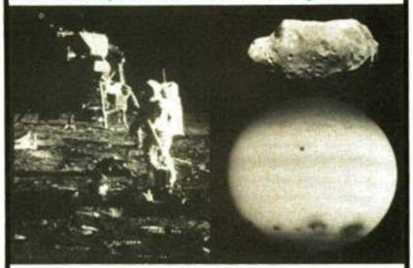

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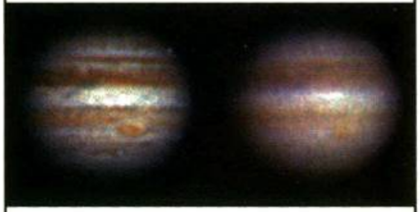

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JUPITER 1994

These photos were taken just 3 minutes apart with the same 10" scope; 22 sec at F/140 on color slide film. Note tiny Europa on the upper right, its shadow on the left, and cloud detail *inside* and around the Great Red Spot,... when the AO-2 is turned on!

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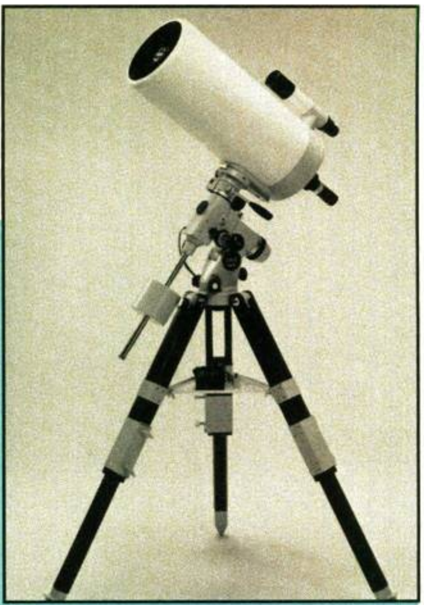
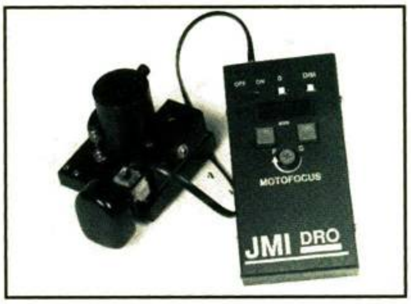


Takahashi Reflector

Takahashi introduces the Mewlon-210, a 210mm f/11.5 Dall-Kirkham compound reflector with a focal length of 2,415mm. The optical tube assembly has a diameter of 244mm and a length of 700mm, weighs 17.6 pounds, and incorporates 10 internal light baffles. It comes with a 7x50 finder, a visual back, and a 1.25-inch ocular adapter. The Mewlon-210 optical assembly can be purchased separately or as part of two accessory packages that include two 5 kilogram counterweights, a 24mm eyepiece, and a star diagonal. The TLS2133 package (pictured) comes equipped with a wooden tripod and an EM-1S mount that has a clock drive and slow motion controls. Package TLS2143 has a wooden tripod and an all-electric mount.

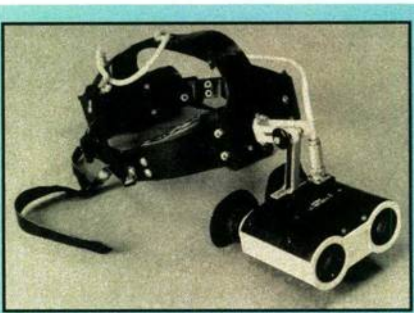
Texas Nautical Repair, 3110 S. Shepherd, Houston, TX 77098, (713) 529-8480. Package TLK2503 (optical assembly only): $2,574; TLS2133: $4,124; TLS2143: $4,821.



Digital Focus Control

When attached to any of JMI's NGF Crayford focusers, the DRO, or Digital ReadOut, electronically displays focuser drawtube position information to within 1/100th of a millimeter. Included is mounting hardware, an optical encoder, and a battery-operated, hand-held display box. On the box is a 9/32-inch, red LED display (with four adjustable brightness levels) that produces drawtube data. A button resets the position readout to zero. Other button controls on the box operate JMI's focusing motors. The DRO works with other popular focusers; write for compatibility information.

Jim's Mobile, Inc., 810 Quail Street, Unit E, Lakewood, CO 80215, (303) 233-5359, fax: (303) 233-5359. $229.



BN20 Night Vision Goggles

These Russian military-issue night vision goggles feature a built-in image intensifier that amplifies ambient light 15,000 times. The unit draws power from a rechargeable battery attached to the headband and yields a nonmagnified 40° field of view. An LED light source in the goggles provides illumination out to 400 feet. The goggles weigh two pounds. Included are a carrying case, two rechargeable batteries, and a battery recharger.

Advanced International Technologies, Inc., Suite E206, 1130 Ten Rod Road, North Kingstown, RI 02852, (800) 945-9103, fax: (401) 294-7960. $550.

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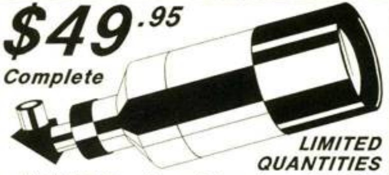
Star Finders, Inc., 2406 Lawrence Street, Eugene, OR 97405, (503) 686-6754, fax: (503) 343-0194. $9.95 plus $5 shipping.

ASTRONOMY & SPACE
1995 WEEKLY CALENDAR

Appointment Calendar

Starry Messenger Press and The Planetary Society have teamed up to produce a weekly appointment book for 1995 with over 100 pages. The book is printed on heavy stock, is spiral bound, and measures 6x9 inches. Each week opens with a full-color space photo and explanatory caption. Every day has lunar phase information, happenings on that date in astronomical history, and room to jot down appointments.

Starry Messenger Press, P.O. Box 6422, Ithaca, NY 14851-6422, (800) 736-6836, fax: (607) 277-0018. $12.95, plus $2 shipping.



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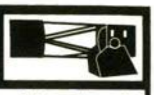

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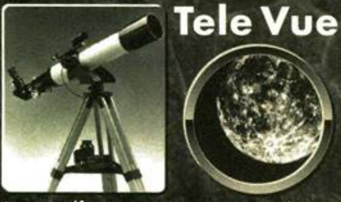

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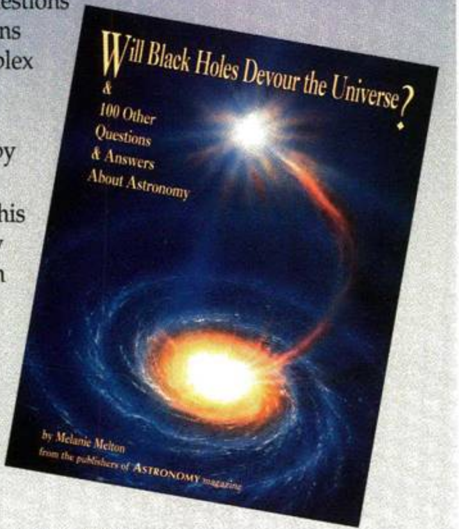
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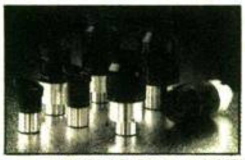

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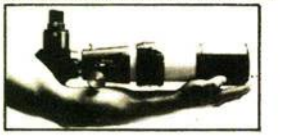

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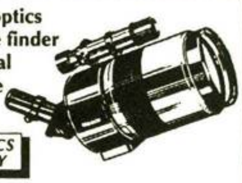

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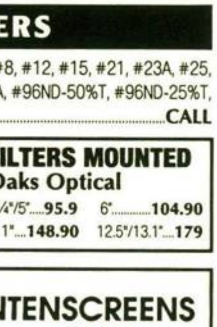

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Aperture	Mounted	Aperture	Unmounted
2.4"	$62.00	2.4"	$52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5 to 4"	66.00
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11"	149.00	11"	139.00
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3.5" to 4"	99.00	3.5 to 4"	79.00
4-1/4" to 5"	125.00	4-1/4" to 5"	110.00
6"	135.00	6"	115.00
8"	159.00	8"	139.00
10"	172.00	10"	152.00
11"	199.00	11"	179.00
12.5" to 13.1"	229.00	12.5" to 13.1"	209.00
14"	259.00	14"	239.00

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12th Annual Deep South Regional Stargaze, Percy Quin State Park, McComb, Mississippi. Sponsored by The Pontchartrain Astronomy Society, Inc. Contact Barry Simon, 820 Emerald Street, New Orleans, LA 70124, (504) 283-7562.

November 3-6
Astro Scopers' Starfest, Chiefland, Florida. Sponsored by the Astro Scopers. Contact Joanne Klein, 8350 81st Street N., Seminole, FL 34647, (813) 397-4235.

November 4-6
Regional Eclipse Convention VII, Montevideo, Uruguay. Sponsored by the Liga Ibero-American Astronomy Club. Contact Ruben E. Garcia, P.O. Box 23.007, 12.800, Montevideo, Uruguay, e-mail (Internet) astronom@fixica.edu.uy or fax 598-2-409973.

November 11-12
Fall Spectacular, Lemon Lake County Park, Indiana. Sponsored by the Calumet Astronomical Society. Contact Stephen J. Miller, Calumet Astronomical Society, (219) 845-9174.

November 12
5th Annual Optics Workshop, Bellingham, Washington. Sponsored by the Whatcom Association of Celestial Observers. Contact Kreig McBride, 402 E. Horton Road, Bellingham, WA 98226, (206) 671-1665.

December 1-3
3rd Annual Star Party, Lake Kissimmee State Park, Florida. Sponsored by the Florida Department of Environmental Protection. Contact George Aycrigg, 14248 Camp Mack Road, Lake Wales, FL 33853, (813) 696-3472.

December 3
4th Annual Star-Be-Que, near Heathcote, Victoria, Australia. Sponsored by the Astronomical Society of Victoria. Contact Perry Vlahos, 9A Hall Street, Cheltenham, Melbourne, Victoria 3192, Australia, 03-583-5930. ☐

Clubs, please submit announcements at least four months before the date of the meeting or event. Readers, include a self-addressed, legal-sized envelope with your request for information.

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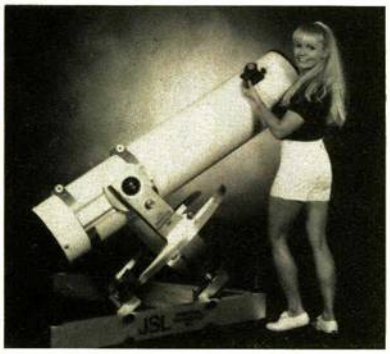

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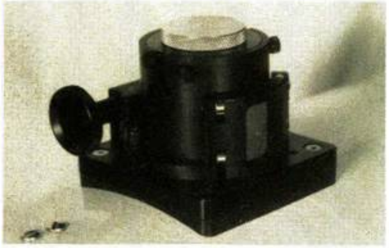

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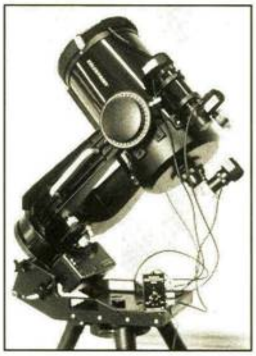

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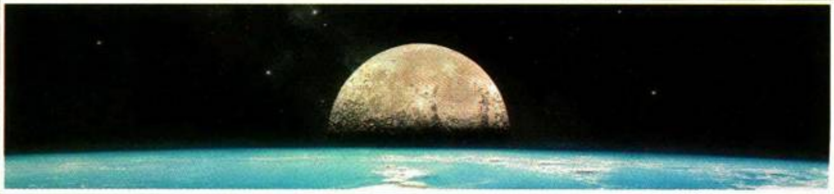

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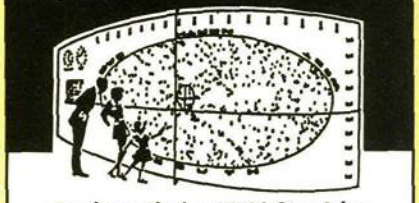

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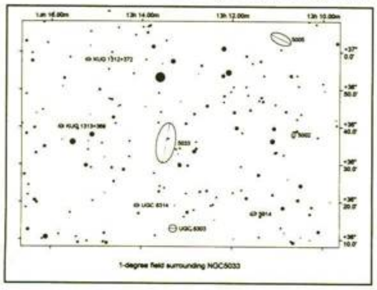

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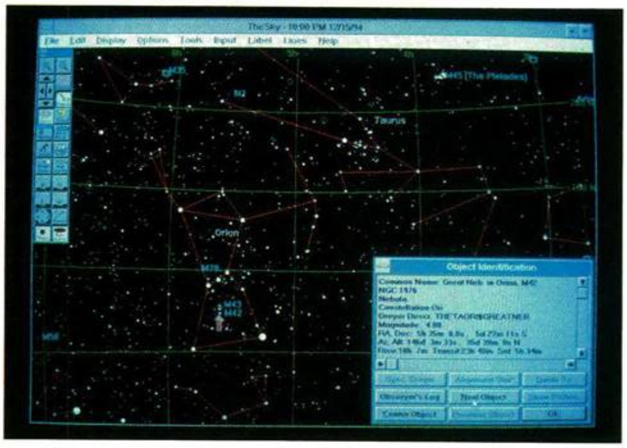

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TheSky is a planetarium-type program widely used by armchair astronomers to explore the sky and by backyard astronomers to locate objects and make finder charts for use at the telescope. The GSC version of TheSky greatly extends the databases used in the program and includes 15 million stars from the Hubble *Guide Star Catalog,* 16,000 stars from the *General Catalog of Variable Stars,* 12,000 double stars from the *Washington Catalog of Double Stars,* 2,000 comets, 7,840 deep-sky objects from the *New General Catalogue,* 5,386 deep-sky objects from the *Index Catalogue,* 1,450 planetary nebulae primarily from the *Perek and Kohoutek* catalog, and 73,000 galaxies from the *Principal Galaxy Catalog.*

Users can select the types of objects to display, the limiting magnitudes for these objects, and the catalogs from which to search for them. Cross references between catalogs are available. Users can search for galaxies using any one of 30 different possible designations.

TheSky (version 2.0) adds several new features, including a star dome display using a stereographic projection ideal for viewing the entire night sky. The CD-ROM contains more than 700 images of the Sun, Moon, planets, and NGC objects. North, east, south, west, and zenith buttons present quick views of these areas of the sky. Galaxies plot with their proper size and orientation, and clusters and nebulae appear their approximate size.

Users can control plotting density from 5,000 to 100,000 objects on the screen for faster or more detailed charts. They can also change the sizes of star dots to optimize the appearance of charts using brightness and contrast controls. The program can center and size the display so it appears the same as *Uranometria 2000.0* charts. And an indicator shows the circular field of view through an eyepiece, the bull's-eye pattern of a Telrad finder, or the rectangular field of a CCD camera.

A-OK! The Wings of Mercury
Innovative Technologies!, 156 Seventeenth Avenue, Brick, NJ 08724-1814, (800) 977-2234. Price: $119.95. Minimum requirements: Macintosh computer, 4 MB of free memory, System 6.0.7, 32-bit QuickDraw, and color monitor. Recommended: a Quadra, Centris, or PowerPC computer, 5 MB of free memory, System 7.1, and a joystick.

A-OK! lets you step into the cockpit of a Mercury capsule (modeled after John Glenn's capsule) and fly a space mission. The screen display simulates the cockpit in every detail, right down to the last switch, gauge, and fuse panel. A window permits viewing Earth, space, and the fiery re-entry of the capsule returning to Earth's surface. Orbital and suborbital flight simulations can start on the launch pad with a countdown sequence, during booster ignition, or in midflight. The digitized voice of the Capsule Communicator (CapCom) relays instructions. Flight plans and checklists appear in a scrollable window that users can position anywhere on the screen. Beginners can start with a fully automatic flight. Those wanting to see if they have the "right stuff" can choose a more difficult playing level that includes multiple equipment failures.

Asteroid Pro (1.6)
Pickering Anomalies, P.O. Box 1214, Belmont, CA 94002. Price: $169.95, plus $5 for shipping. Minimum requirements: 80386-

based computer, 3 MB of free memory, DOS, color display, and a hard drive with 40 MB of free space. Mouse and a math coprocessor recommended.

When an asteroid passes in front of, or occults, a star, it casts a shadow on Earth. The size of the shadow helps astronomers determine the size and shape of the asteroid. But the trick is knowing when and where the occultation will occur. Most planetarium-type programs aren't up to the complex calculations needed to determine the shadow path but *Asteroid Pro* is. It will search for occultations visible during a given month and from a particular locale. Users can filter lists of possible occultations by asteroid brightness, star brightness, and angle from the Sun.

The program includes databases detailing the positions of 400,000 stars (from the *Astrographic Catalog of Reference Stars* and the *Positions and Proper Motions* catalog) and the latest orbital elements of 5,500 asteroids. The sizes of asteroids are either measured values or calculated ones determined from the asteroid's brightness. Orbital calculations include gravitational perturbations by the planets and other asteroids, and the program will suggest automatically to the user when a smaller time step should be used to maintain precision in the calculations. Users can export asteroid orbital elements for use in other programs, such as *Epoch 2000, TheSky*, and *Dance of the Planets.*

PC-Sky (1.1) Upgrade
CapellaSoft, P.O. Box 3964, La Mesa, CA 91944, (619) 460-8265. Price: $99, plus $5 for shipping in the U. S. and Canada; upgrade from PC-Sky 1.0: $5, plus $1 shipping. Minimum requirements: 80286-based computer, 535 KB of free memory, DOS 3.3 or OS/2 2.0, VGA display, and a hard drive with 3.2 MB of free space. Mouse and a math coprocessor recommended.

CapellaSoft has added several new features to its sky simulation program *PC-Sky* since our review in the August 1994 AstroBytes. The SVGA display is improved, showing better color and star images. Telescopic views now include 3-inch aperture scopes, in addition to the previously simulated 6- to 24-inch views. Mouse actions seem smoother. And the dynamic range of the star brightnesses has changed to make it easier to see faint stars.

MegaStar for Windows (1.0)
E.L.B. Software, 8910 Willow Meadow Dr., Houston, TX 77031-1828, phone/fax (713) 541-9723. Price: $99; $20 for upgrade from DOS version. Minimum requirements: 80386-based computer, 4 MB of free memory, Windows 3.1, VGA display, CD-ROM drive, a mouse, and a hard drive with at least

(continued on page 110)

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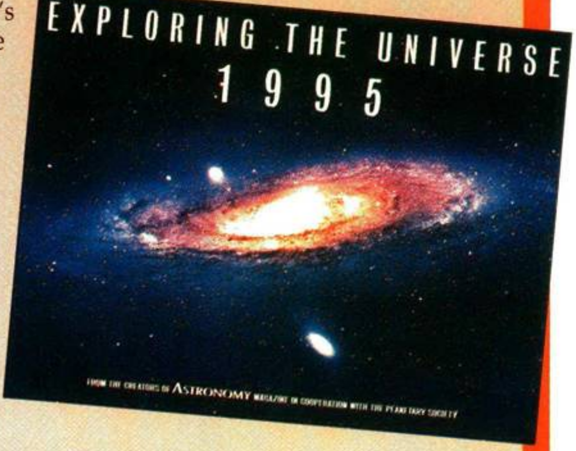
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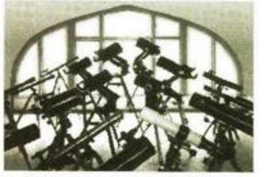

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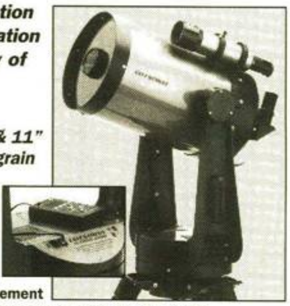

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3 MB of free space. Recommended: a math coprocessor.

This version of *MegaStar*, a deep-sky charting program, works in the Windows environment, utilizing pull-down menus for program commands and the Windows printer drivers for producing star charts on almost any printer. (See the October 1993 AstroBytes for a review of *MegaStar.*) For example, setting the field size is now a matter of clicking on a button to choose from a range of values from 15' to 20°; keyboard entry of values also works. E.L.B. has refined many of the functions and improved the printed chart quality. A new feature is the calculation of asteroid and comet positions from orbital element information.

Star Probe

Artemis Science Curriculum and Software, 3211 NE 50th, Portland, OR 97213, (503) 284-7446. Introductory price: $45, includes license for use on up to five computers. Minimum requirements: Macintosh, color display, 4 MB of memory, system 7.X, and 8 MB of free space on a hard drive.

Planetarium-type programs ably show the positions of stars and their grouping in asterisms and constellations. But they fail to reveal the intimate details of stars. *Star Probe* presents several tools for exploring the physics and life cycles of stars. By clicking on a star map, the user can select stars and then view their spectra. From a detailed look at the lines in the stellar spectra, one can group the stars by type and determine their temperatures.

From the temperatures and the luminosities of the stars, the user can build a Hertzsprung-Russell diagram. Later activities teach the user how to interpret this diagram to learn how stars change in size, temperature, and luminosity as they age. Another activity takes the user inside a star, showing how the core soars to the incredible temperatures needed to generate the energy that sustains the star. Although these activities were written for use in high schools and in college astronomy classes, interested armchair astronomers might find *Star Probe* of interest.

MarsBook

Human Code, 1397 West Avenue, Austin, TX 78701; available from EduCorp, 7434 Trade Street, San Diego, CA 92121-2410, (800) 843-9497. Price: $17.95. Minimum requirements: Macintosh II computer, 8 MB of memory, System 7.X, QuickTime, color monitor, and a CD-ROM drive. A 24-bit color display is recommended.

NASA designers wanted to present plans for an Initial Mars Habitat to NASA managers and the Congress in a way that made viewers feel like they were walking through the structure. Human Code came up with this presentation that allows users to inspect the structure from any angle outside, strip off fuel tanks and other external gear to view the habitat itself, and to amble through the two levels inside to look at crew quarters, medical facilities, and work areas. Computer-aided design (CAD) diagrams show the floor plans of the module, designed for six persons living on Mars for 500 days.

Along with *MarsBook*, the CD-ROM contains another program called *LunarMod*. This presentation shows CAD diagrams and rendered drawings of an Initial Lunar Habitat that NASA designed using a space station Freedom module. It too will serve six astronauts but is much smaller, being 14 feet in diameter and 39 feet long. A meter-thick shield of lunar soil will protect astronauts from micrometeorites. Clicking on the screen reveals text that explains the function of each section of the habitat.

Expert Astronomer for Windows

Expert Software, 800 Douglas Road, North Tower, Suite 750, Coral Gables, FL 33134-3128, (800) 759-2562, fax (305) 448-2074. Price: $14.95. Minimum requirements: 80386SX-based computer, Windows 3.1, 2 MB of memory, hard drive with 1.8 MB of free space, mouse, and VGA display. Program comes on a 3.5" disk; 5.25" disks are available and cost $3 for shipping. An SVGA display and 4 MB of memory recommended.

This offering is a Windows version of *Expert Astronomer* for the Macintosh (see the review in the July 1993 AstroBytes). It displays the planets, 9,100 stars, and 110 deep-sky objects. The program can automatically search for conjunctions (when two objects appear close in the sky) and oppositions (when a planet appears opposite the Sun in the sky). A Find feature makes it easy to locate stars, planets, and constellations. Users can animate sky events such as eclipses or view the sky from another planet or above it with the space shuttle tool. The Windows interface permits the printing of star maps on any Windows-supported printer.

Comet Smash CD-ROM

Network Cybernetics Corporation, 4201 Wingren Road, Suite 202, Irving, TX 75062-2763, (214) 650-2002, fax (214) 650-1929, e-mail SL9-info@ncc.com for information and SL9-orders@ncc.com for orders. Price: $39 plus $3 shipping in the U. S. Requires a CD-ROM drive (ISO-9660 capable).

Many images of Comet Shoemaker-Levy 9's impact on Jupiter in July raced through the wires of the Internet shortly after each fragment crashed into the Giant Planet. Network Cybernetics collected on this CD-ROM 714 of the best images (almost 170 MB worth), 50 animations and sequences of images (another 45 MB), and 848 text files containing observing reports and information files. These contributions came from more than 30 observatories. Image files use EPS, FITS, GIF, JPEG, PostScript, and TIFF formats. The animations and movies use FLC, FLI, MPEG, and QuickTime formats. For users that don't have image processing programs, the CD-ROM includes shareware programs for viewing the images on OS/2, DOS, and Mac computers (you may owe additional fees payable to the developers for the use of their programs).

Astronomy on the Internet

Suppose you know a user's name but don't know their computer address (also called a subdomain). Check *!%@:: A Directory of Electronic Mail Addressing and Networks*, by Donnalyn Frey and Rick Adams (O'Reilly and Associates, Inc., 1994, ISBN 1-56592-046-5, 662 pages, $9.95). There you can find, for example, that the address of Slippery Rock University of Pennsylvania is sru.edu. The book also explains how to address mail on the Internet that is destined for networks such as DFN, EARN, FidoNet, JANET, and more than 200 others spread over the world. And it tells how to decode addresses such as xyz0123%ABC@defghj11.XXX into plain English.

Readers wanting the news and commentary about astronomy should try the Usenet newsgroup sci.astro. Looking for a computer program that calculates moonrise and moonset times or tracks satellites? Use anonymous ftp (file transfer protocol) to access the programs from astro/ at hanauma.stanford.edu and /pub/astronomy at qiclab.scn.rain.com. Wide Area Information Server (WAIS) users can get a list of 9,000 astronomers called astropersons from ndadsb.gsfc.nasa.gov.

The National Geophysical Data Center now makes many of its databases available through the Internet. These include solar magnetic field data, solar indices such as sunspot numbers, DMSP weather satellite data, and Earth climate and seismological data. One can access the Geophysical On-line Data using anonymous ftp from host ftp.ngdc.noaa.gov, Gopher at gopher.ngdc.noaa.gov (for more information on the Gopher master server, contact gopher@boombox.micro.umn.edu), or through Mosaic at the World Wide Web home page http://www.ngdc.noaa.gov/ngdc.html (choose "open URL" first to open the Uniform Resource Locator). For information about Mosaic, a hypertext reader, contact the National Center for Supercomputing Applications at mosaic@ncsa.uiuc.edu. □

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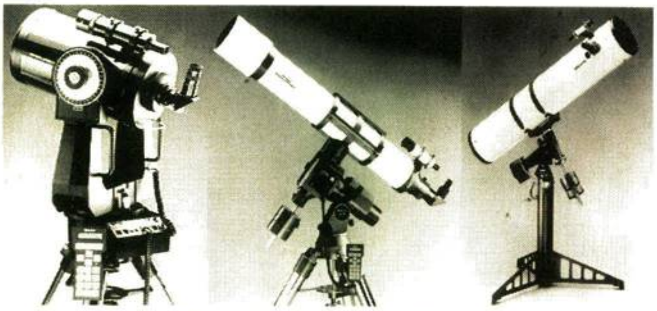

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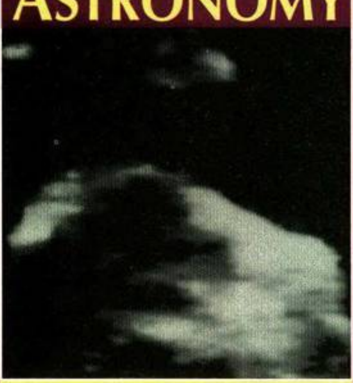

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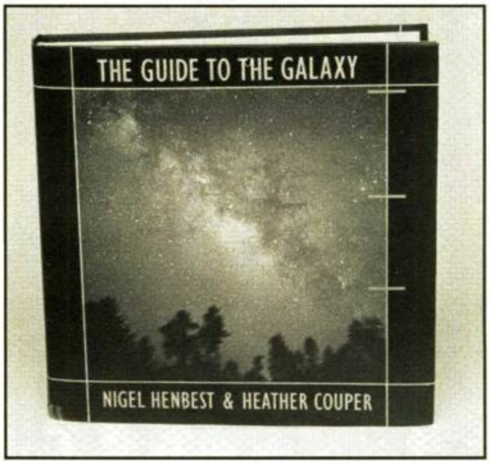
Know Your Galaxy

The Guide to the Galaxy
Nigel Henbest and Heather Couper, (Cambridge University Press, 1994), ISBN 0-521-30622-1, 263 pages, hardcover, $49.95.

For more than two centuries, using telescopes made from glass and wire mesh, astronomers have slowly and meticulously pieced together a picture of the galaxy we call home, our Milky Way. *The Guide to the Galaxy* gives readers a guided tour of that picture, through historical narrative, archival photos, lavish photos of Milky Way galaxy objects, and artists' renderings of what various regions of our spiral-shaped looks like from afar.



Astronomy: Jim Forbes

The tour begins at antiquity, where the realm of cosmology and philosophy blended together in an amalgam of observation and speculation. It wasn't until 1610, when Galileo turned his "optick tube" on a glittering Milky Way over Padua, that our Galaxy's true nature started to be glimpsed. He concluded that it was "in fact nothing but congeries of innumerable stars grouped together in clusters." In the 18th century, German Philosopher Immanuel Kant, better remembered today for his work on human reasoning, ventured that the Galaxy was a flat distribution of stars, just one of many in the universe. In England, William Herschel, armed with a 48-inch reflector, set out to construct a model of that star distribution. His "grindstone model" placed the Earth and Sun at the center of the universe. Herschel also noted some "spiral nebulae," which he took to be swirling clouds of gas or irresolved stars within our Galaxy.

In the early twentieth century, with the advent of larger scopes and photography, these spiral nebulae were resolved into vast accumulations of stars, perhaps galaxies in their own right. Measurements of variable stars within these "extragalactic" nebulae did indeed establish that they were far outside our own system of stars. In the 1930s, Edwin Hubble set out to measure their distance and classify their shapes. Great inroads were made in defining the universe's size and make-up. But what of our own Galaxy?

Classifying external galaxies, it turned out, was easy compared to deducing the structure of our Milky Way. The task was immensely complex because we are smack in the middle of the action. Harlow Shapley gleaned a rough idea of the Galaxy's size and our position within it by looking at the distribution of globular clusters. In 1950, William Morgan confirmed the existence of two nearby spiral arms by plotting the positions of young O- and B-type stars. Finally, in the late 1950s, the Milky Way's true spiral nature was revealed when Dutch astronomer Jan Oort used radio astronomy to measure the distribution of hydrogen clouds and their motions.

Today astronomers use not only optical and radio telescopes to study our home galaxy, but space-borne gamma-ray, X-ray, ultraviolet, and infrared satellites and telescopes as well. It's the nature of our Galaxy's components — its center, halo region, gas, stars, and dust — that demands most of the attention of astronomer's today.

Henbest and Couper divide *The Guide to the Galaxy* into chapters that cover galactic regions. They present the latest in scientific thinking on interesting objects found in each area. Chapters begin with color-coded maps that show the spatial relationships among stars, clusters, nebulae and other objects within a spiral arm. Opposite these maps are region renderings that use colors strangely loud and somewhat distracting.

This criticism aside, *Guide to the Galaxy* accomplishes what it sets out to do: Provide a survey of what we know today of the Milky Way and how we arrived at that knowledge. It's a story of where we have been and how far we have come on our journey to understand not only the Milky Way, but galaxies throughout the universe. — *John Shibley*

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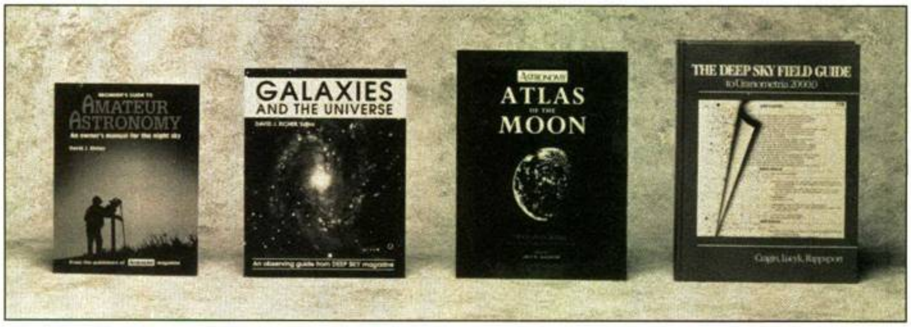

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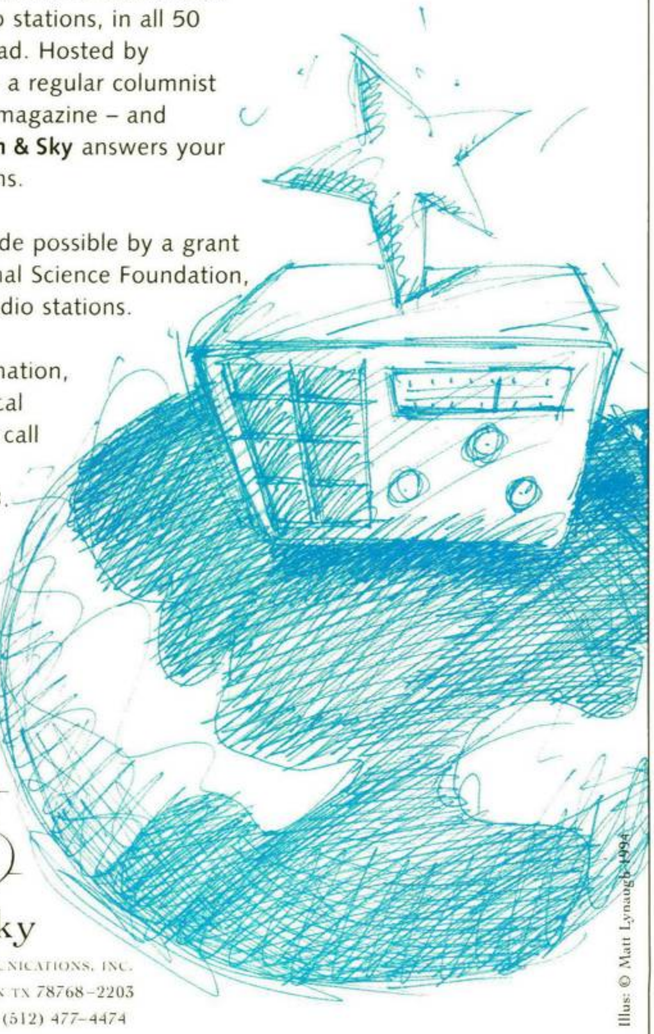

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More New Books

Jupiter, the Giant Planet

Reta Beebe, (Smithsonian Institution Press, 1994), ISBN 1-56098-417-1, 248 pages, hardcover, $29.95.

This is another installment in a series of solar system books, the first two dealing with Mercury and the Sun. Beebe, who specializes in planetary atmospheres and served on the Voyager spacecraft imaging team from 1977 to 1990, focuses on four areas: the history of Jovian exploration, Jupiter's atmosphere and interior, its satellites and rings, and its magnetosphere. In the book's concluding section she presents future plans for observing Jupiter and studies the dynamics behind Comet Shoemaker-Levy 9's collision with the planet.

Within each chapter, topics have bolded section headers, which makes browsing easy. Some techniques and terminology that might prove confusing to the casual reader are fully explained in a number of appendices. There are no observational tips here for amateurs, just up-to-date information, complete with pictures, tables, and diagrams on what astronomers know about Jupiter and its family of moons. *Jupiter, the Giant Planet* summarizes the state of Jovian studies before the arrival of Galileo in 1995.

Galileo: A Life

James Reston, Jr., (HarperCollins, 1994), ISBN 0-06-016378-X, 319 pages, hardcover, $25.

This book offers an entertaining view of Galileo's life, from his birth into the family of a musician/wool merchant, through his brilliant and tempestuous years as a mathematician, physicist, and astronomer, to his death while under house arrest after butting heads with the Vatican over publicizing the Copernican model of the universe. Galileo was brilliant and, when he wanted something, knew how to play politics.

But he could not stand ignorance and pomposity. When right, he felt the world certainly had to take note of it, and this was his Achilles' heel. Such outspokenness created many powerful enemies, not the least of whom were in the Roman Catholic Church. Hauled before an inquisition for the manner in which he wrote about Copernican theory, 70-year-old Galileo was sentenced to a penance of psalm recitations each week for three years. Incidentally, his book *Dialogue* was *banned* by the Church until 1835; in 1992 the Vatican said it erred in condemning Galileo and rehabitated him (see AstroNews, February 1993).

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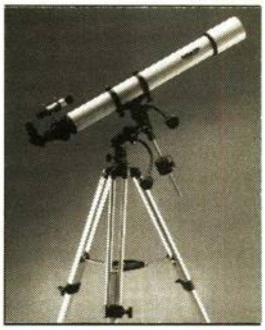

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ASTRONOMY BOOKS

Skywatching

David H. Levy, (The Nature Company, 1994), No ISBN number, 290 pages, hardcover, $24.95.

This attractive coffee-table book has a profusion of color photos and illustrations that serve as a springboard for someone just starting in astronomy. The text concisely reviews the hobby and covers the history of the science, the nature of celestial objects, as well as when to look and how to observe and photograph them. The book's middle section has seasonal and constellation star charts created by celestial cartographer Wil Tirion. Seasonal charts have lines that delineate observing horizons at various latitudes. Following the seasonal maps, in alphabetical order, are maps of each constellation plotted with naked-eye stars and conspicuous deep-sky objects. A discussion of mythology, descriptions of notable telescopic and binocular targets, and photos of deep-sky objects accompany each map. The margin contains a scale that uses an out-stretched hand to indicate the constellation's size, and a key that ties each constellation to the seasonal charts. *Skywatching* is full of information and advice on how to begin enjoying the hobby of astronomy.

Atmospheric Halos

Walter Tape, (American Geophysical Union, 1994), ISBN 0-87590-834-9, 143 pages, hardcover, $40.

Ice crystals in Earth's atmosphere create some pretty spectacular light shows. Depending on crystal shape, formations such as halos, pillars, arcs, anti-suns (or moons) can occur in all areas of the sky, day or night. Walter Tape has gathered into this book not only the scientific explanation behind atmospheric halos, but dozens of color photos of stunning displays taken from around the world, most taken during a recent Antarctic halo study. In many cases, halo photos are shown side-by-side with pictures of the very crystals that created them, collected by scientists using weather balloons. Chapters fully explain the interplay of light and crystal geometry and the role of viewer location, solar elevation, and weather on the outcome of certain displays. The book also has diagrams generated by a computer program that simulates halos. One chapter talks about elaborate displays recorded in history, the likes of which have never been seen again. An appendix includes tips on how to photograph displays. *Atmospheric Halos* is an excellent reference book and atlas to such rare and spectacular sky phenomenon. ☐

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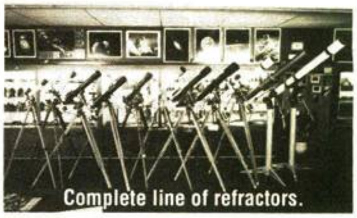

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READINGS & CREDITS

The Crab Nebula (page 42)

The Crab Nebula by Simon Mitton, (Charles Scribner's Sons, 1978). The complete story of the Crab Nebula, from its fiery birth in the supernova explosion of 1054 to the discovery of a rapidly spinning pulsar at its heart in the late 1960s, and beyond.

The Debut of Galaxies (page 44)

The Big Bang by Joseph Silk. (W. H. Freeman and Company, 1989). Describes how density ripples became galaxies and how clusters of galaxies formed.

"Everything You Wanted to Know About the Big Bang" by Richard Talcott. ASTRONOMY, January 1994. An excellent introduction to basic cosmological concepts, including why the cosmic background radiation doesn't come from one point in the sky.

Under the Southern Sky, Part Two (page 78)

Astronomical Objects for Southern Telescopes by E.J. Hartung (Cambridge, 1984). An extensive compilation of observations of Southern Hemisphere objects made with a variety of telescopes. The notes are precise and convey a great amount of data for each object.

Beyond the Solar System: 100 Best Deep-Sky Objects for Amateur Astronomers by David J. Eicher (Kalmbach, 1992). An illustrated catalog of the greatest star clusters, nebulae, and galaxies in both hemispheres, with observing tips and basic data.

Burnham's Celestial Handbook by Robert Burnham, Jr. (Dover, 1978). A massive, three-volume compendium of basic data, photographs, charts, and maps relating to stars and deep-sky objects. Organized by constellation, the work has significant coverage of bright objects in the Southern Hemisphere.

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Illinois/NCSA; **p. 50:** John Bahcall, Institute for Advanced Studies, et al./NASA/HST FOS; **p. 56:** Mirco Villa, Scotch P800-1600 film, December 15, 1991; **p. 60:** Keith Ward; **p. 61:** Harold Moore, October 4, 1988; **pp. 66-67:** Lee Vande Visse; **p. 70, bottom left:** James McGaha, 24-inch f/5 reflector, HPC-1 CCD camera, taken on May 5, 1994; **top right:** Jeffrey D. Beish, 16-inch f/7 reflector at 225x and 382x at 7:35 p.m. EDT on July 16, 1994; **pp. 70-71:** Ralph Merletti, taken on July 20, 1994, at Riverside Community College, California; **p. 71:** Donald C. Parker, 16-inch f/7 reflector, Lynxx CCD camera, images taken on july 17, 22, 24, and 26, 1994; *center:* Carlos E. Hernandez, 16-inch f/7 reflector at 360x at 9:25 p.m. on July 18, 1994; *bottom:* Carlos E. Hernandez, 16-inch f/7 reflector at 382x at 8:20 p.m. EDT on July 30, 1994; **p. 72, top:** Ronald E. Royer, Dave Phelps, and Rick Sorensen, 12.5-inch reflector, Starlight Xpress CCD camera, taken on July 25, 1994; **middle:** Thomas A. Dobbins, 10-inch reflector at f/34, Starlit Technology CCD videocamera with Schott KG1 filter, taken at 9:14 p.m. EDT on July 23, 1994; **bottom left:** Randy Pakan, 16-inch reflector at 180x, sketch made at midnight EDT on July 21, 1994; **bottom right:** Chris Cook and Jim Janusz, 6-inch refractor at f/150, T-MAX 100 film, 1.5-second exposure on July 28, 1994; **p. 73, top series from left:** Greg Terrance, 16-inch reflector at f/15, ST-6 CCD camera, taken on July 18, 1994, 16-inch reflector at f/15, ST-6 CCD camera, taken on July 21, 1994, 16-inch reflector at f/15, ST-6 CCD camera, taken on July 25, 1994; **middle:** Ralph E. Mackenstein, 60mm refractor at 72x, sketch made at 9:30 p.m. EDT on July 19, 1994; **bottom:** Ronald W. Kohl, 20-inch Cassegrain, STAR I CCD camera, 0.1-second exposure at 9:35 p.m. EDT on July 19, 1994; **p. 74, top:** Gregory Terrance, 16-inch reflector at f/15, ST-6 CCD camera, taken on August 22, 1994; **bottom left:** A. Vincent, 8-inch SCT, Fuji Super HG 400film, 1-second exposure, taken on July 20, 1994; **bottom right:** Mark Schmidt, 14-inch SCT at f/95, Ektachrome 100 film, 3-second exposure taken on July 27, 1994; **p. 75, top left:** Ed Couture, 11-inch SCT, Fuji Reala 100 film, 5-second exposure taken on July 19, 1994; **top right:** 8-inch SCT at f/250, Kodak Gold 200 film, 3-second exposure taken on July 28, 1994; **bottom left:** Myron E. Wasiuta, 10-inch reflector at f/24, Electrim EDC-1000 CCD camedra, Sratten #25 filter, taken on July 20, 1994; **bottom right:** Donald G. Bruns, 10-inch SCT Fuji Velvia 50 film, 28-second exposure, taken on July 22, 1994; **p. 76, top:** Donald C. Parker, 16-inch f/7 reflector, Lynxx CCD camera, images taken on July 17, 23, and 25, 1994; **bottom left:** Mark Schmidt, 14-inch SCT at f/95, Ektachrome 100 film, 4-second exposure at 10:17 p.m. EDT on July 29, 1994; **bottom right:** Jonathan Dietch, 8-inch reflector at f/275, Kodak Royal Gold 1000 film, 1-second exposure at 11:55 p.m. EDT on July 21, 1994; **p. 77, top left:** David Hanon, 7-inch refractor at f/56, ST-4 CCD camera, taken at 9:50 p.m. EDT on July 24, 1994; **right:** David Hanon, 7-inch refractor at f/56, ST-4 CCD camera, taken at 10:32 p.m. EDT on July 28, 1994; **bottom:** Jeffrey D. Beish, 16-inch f/7 reflector at 382x and 585x at 8:22 p.m. EDT on July 24, 1994; center: Carlos E. Hernandez, 16-inch f/7 reflector at 382x at 10:00 p.m. EDT on July 26, 1994; bottom: Carlos E. Hernandez, 16-inch f/7 reflector at 382x at 9:00 p.m. EDT on July 31, 1994; **pp. 78-83:** Luke Dodd; **pp. 84-87:** Jim Forbes; **p. 89, top:** Keith A. Corban, 28mm lens at f/3.5, Kodak Ektar 1600 film, 210-minute exposure taken on August 12, 1994; **bottom:** Dan Smiley, 24mm lens, Fuji Super HG 400 film, taken on August 12, 1994; **p. 90, top:** Len Nelson, 28mm lens at f/2.8, T-MAX 3200 film, taken on August 12, 1994; **middle:** Andy Druga, 50mm lens at f/1.7, Fuji Super HG 400 film, 5-minute exposure taken on August 12, 1994; bottom: Chuck Vaughn, 7.9-inch f/4 hyperbolic astrograph, hypersensitized Tech Pan film, 45-minute exposure taken on August 4, 1994; p. 91: Vic Winter, 8mm lens at f/2.8, Kodak Ektapress 1600 film, 20-minute exposure taken on August 12, 1994; **p. 92, top:** John A. Volk, 105mm lens at f/2.4, Fuji Super HG 400 film, 40-minute exposure taken on August 12, 1994; **middle:** Bill and Sally Fletcher, 16-inch f/4.5 reflector, hypersensitized Tech Pan film, tricolor composite using 65-minute red, 90-minute green, and 125-minute blue exposures; **bottom left:** Frank J. Melillo, 8-inch f/10 SCT, hypersensitized Tech Pan film, 30-minute exposure showing 10-minute intervals of motion separated by 15-minute gaps, taken on August 30, 1994; **p. 93:** Mark E. Seibold, 28mm lens at f/2.8, Kodak Royal Gold film, 45-minute exposure with a handheld flash to illuminate the tree; **p. 106:** Jim Forbes.

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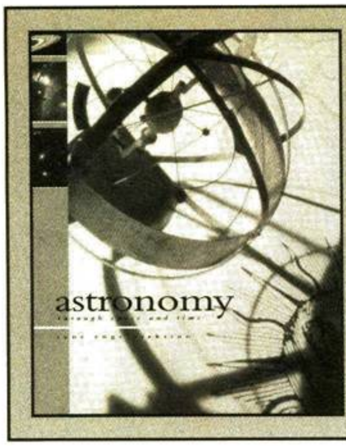

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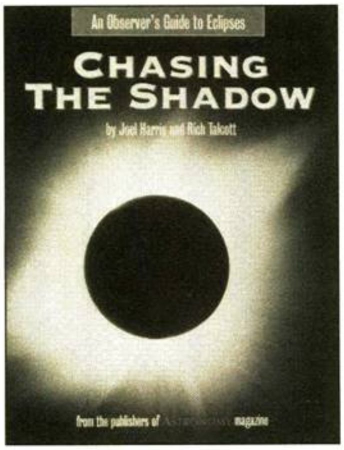
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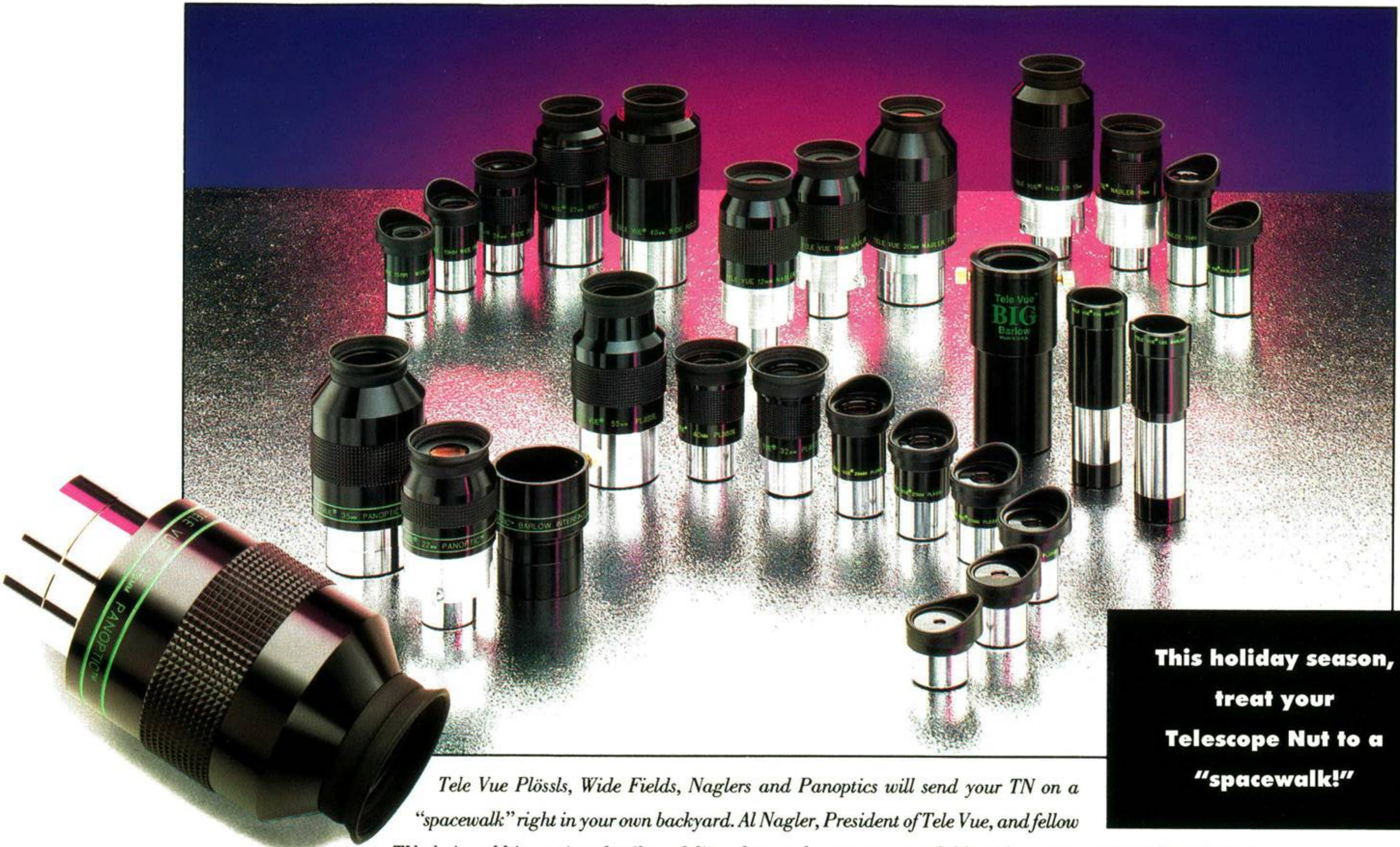

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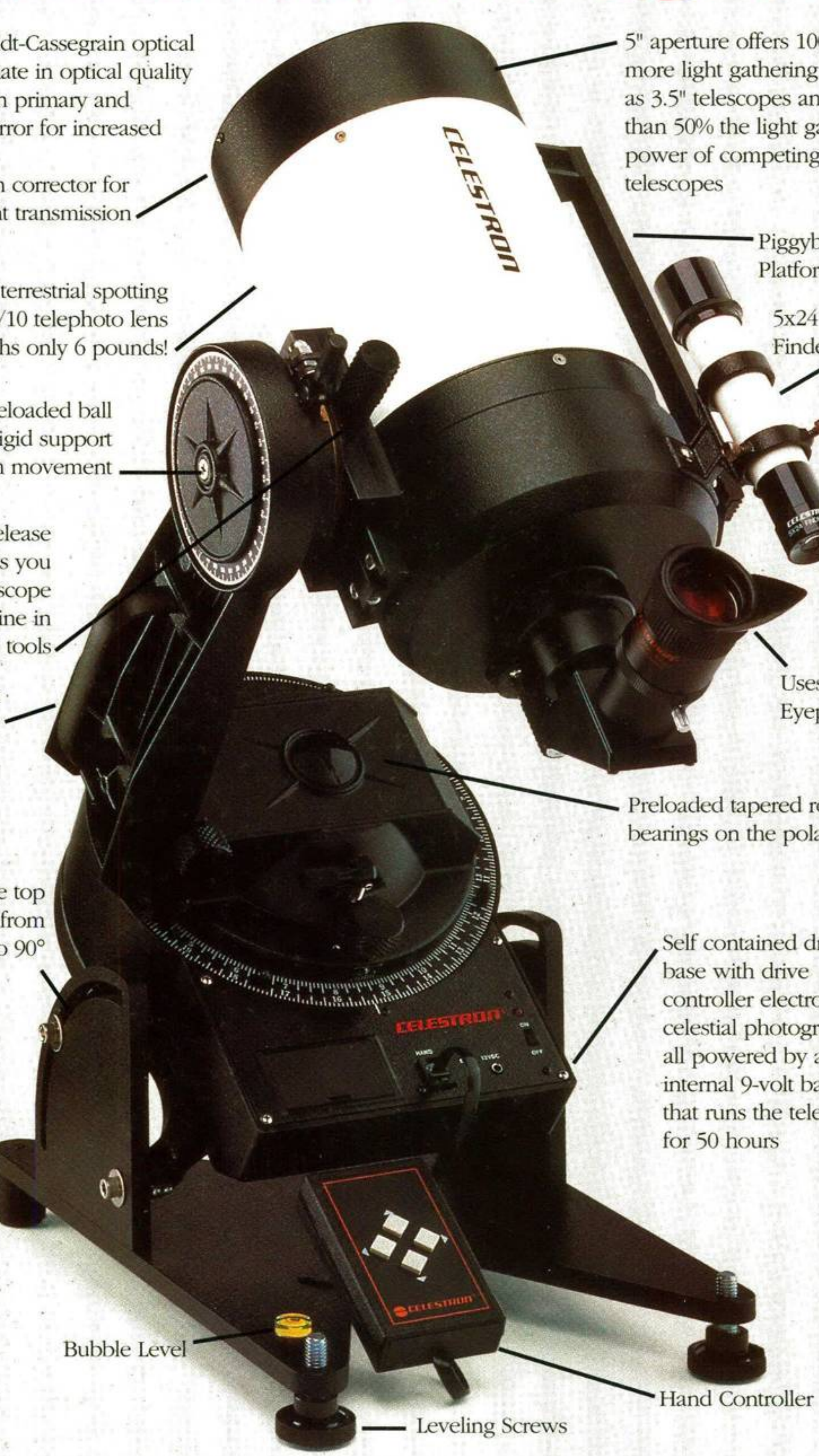

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